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AMERICAN JOURNAL OF OPHTHALMOLOGY

VOLUME 25 SEPTEMBER, 1942 NUMBER 9

A QUANTITATIVE STUDY OF THE CELLS AND FIBERS IN THE NUCLEUS: NERVE COMPLEXES OF THE FOURTH AND SIXTH CRANIAL NERVES*†

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INTRODUCTION

The purpose of this study of the fourth and sixth cranial nerves and nuclei was to investigate the number of fibers in relation to the number of cells in the so-called nuclei of these nerves at various ages of normal man. It was considered of primary importance to attempt to establish the numerical relationship between fibers and cells; namely, to see whether the number of cells was equal to the number of fibers or whether, because of the various connections of unknown complexity between these cells and those of the oculomotor nuclei and the other cranial-nerve nuclei, there might exist a difference.

If there are fewer cells than motor fibers, a part of the cells of origin must lie outside the circumscribed masses of gray matter that are the respective motor nuclei. More cells than fibers, on the other hand, would indicate that there must be nervous connections other than to the peripheral nerves, which are usually associated with these nuclei, the fibers of which are supplied at least by some of their cells.

There is clinical and physiologic evidence that there must be connections between the different oculomotor nuclei because of the smooth interplay and reciprocal action that exist between the muscles of the eye, not to mention additional nervous pathways connecting the nuclei of the midbrain to the hindbrain and even to the spinal cord. A logical query might be the location of the cell stations of these oculomotor connections. Do they exist in their respective nuclei, as generally recognized, or are there cells located elsewhere that are responsible for these associated impulses? Numerical data should have a distinct bearing on these questions, and at least limit the possibilities.

The problem of determining the ratio of motor fibers to cells of origin in these nerves is not so simple as might be expected, for the oculomotor nerves contain fibers that have been recognized clearly as being sensory, and allowance must be made for this type of fiber. The cells of origin of these sensory fibers are wholly unknown. The question naturally arises as to whether there are enough cells of proper morphology in the nuclei of these nerves. If more motor cells than motor fibers were present, the situation would agree well with the anatomic evidence in support of the present-day conception that the median longitudinal fasciculus is one of the chief connecting links

* Abridgment of thesis submitted to the Faculty of the Graduate School of the University of Minnesota in partial fulfillment of the requirements for the degree of Ph.D. in Ophthalmology.

† Read at the thirteenth scientific meeting of the Association for Research in Ophthalmology, Atlantic City, June 9, 1942.

between the nuclei of the oculomotor nerves and the rest of the cranial nuclei, since this tract is located so close to the nuclei of the ocular nerves.

Furthermore, by establishment of a quantitative value for cells in the normal oculomotor nuclei and nerves, a basis for a more exact interpretation of these nuclei in pathologic conditions can be made. So few determinations of the number of fibers have been performed that there is an urgent need for establishment of a more reliable standard.

By such quantitative methods, questions as to the amount of involvement of the nuclear cells necessary before paresis of the extraocular muscles can be recognizable clinically may possibly be approached.

There must be a minimum threshold and a relatively large "factor of safety" present in the oculomotor apparatus as in all other structures of the human organism if reasoning by analogy is to be allowed. The question of the normal reserve and the minimum fraction of the normal number of fibers that is compatible with adequate ocular rotation await quantitative determination.

The literature shows that only a few attempts at such quantitative determinations have been made. Whereas eight investigators[1–4, 6, 7, 9, 10] have counted nerve fibers in these cranial nerves, only one specimen was used in most cases, and more than four counts were never done on any one kind of nerve (table 1).

TABLE 1

NERVE-FIBER COUNTS IN THE LITERATURE

Author	3d Nerve	4th Nerve		6th Nerve	
		Prox.	Dist.	Prox.	Dist.
Rosenthal	15,000	1,200		2,600	
Krause	15,000				
Merkel		2,147			
Tergast				3,610	
Björkman and Wohlfart	24,000	3,400		6,600	
Bors	13,159	1,602	1,782	3,862	4,698
Chiba				5,949 5,157 Rt. 4,422 Lt. 5,661	
Maleci		2,596	2,645 (50 mm.)	6,634 6,762	6,775

It was found that one other worker (Maleci,[6] 1936) had undertaken a study similar in many respects to this study. Maleci[5] (1934) reviewed the literature and was unable to find any previous quantitative work on brain-stem nuclei. He counted the cells in one abducens nucleus in three cases and one abducens nerve in two cases, but this material came from different specimens and was in no way related. His blocks were cut in serial section at 25 microns, a figure which I suspect must have introduced an error in the total cell counts because of the factor of thickness.

Although it is true that nucleoli can be recognized in a clear section of this thickness, it requires considerable focusing up and down in order to include all the cells. It was felt that in my sections, which were cut at 10 microns, an easier and more nearly accurate method of study of the cells was provided. It is not desirable to cut the sections thinner than 10 microns, since if thinner sections are cut the margin of error caused by split nucleoli may be increased.

In specimens from a person 33 years old Maleci[5] counted 3,810 cells; in specimens from a person 40 years old, 3,970 cells; in specimens from a person 42 years old, 4,207 cells. For the ratio of cells to fibers, he obtained 100 cells to 169 fibers. If he excluded the 15 percent of small fibers, his calculations resulted in a 44-percent increase of fibers in excess of cells.

Materials, Methods, and Counting Procedure

The nerve and nucleus specimens were collected from 32 normal human brains. If at all possible, two sections for study were procured from each nerve. One section was stained for myelinated fibers and the other for the total number of fibers. In the case of the fourth nerve, when the length had been well preserved, two sections were taken distally. In such instances, one fourth nerve would supply four sections for counting. On this basis 113 sections of the fourth nerve, 77 sections of the sixth nerve, 40 sections of the third nerve, 53 nuclei of the fourth nerve, and 49 nuclei of the sixth nerve actually were studied. Counts of the fibers of the third nerve were made so that counts given in the literature could be checked but these do not enter into the main topic of this thesis. The specimens were all considered to be free from pathologic change and in each case they were obtained from persons who apparently had been free from extraocular-muscular disturbances.

In the specimens in which a rather long fourth nerve was retained, small samples were taken at a distance of 25 mm. as well as near the brain stem. Most of the nerve sections, however, were cut proximally at a distance of 10 mm. from their point of exit from the brain stem. At this distance the dura invested the nerve sufficiently well so that the transverse section became nearly uniform, except in certain cases in which the sixth nerve was involved, where the septa were not entirely united.

Each nerve was studied to determine the number of myelinated nerve fibers present and also the total number of fibers. For the former purpose, the nerves were treated with Weigert's myelin-sheath mordants for several days, embedded in paraffin, sectioned at 6 microns, and stained by the Mallory-Heidenhain (azocarmine-orange G-aniline blue) method. In order to make an enumeration of the total number of nerve fibers in each nerve, the Bodian silver technique was employed. These sections were cut at 10 microns. For this purpose, the formalin-fixed tissue was treated with acetic acid and stained with activated strong silver protein (protargol).

Counting of the nerve fibers was performed by the placing of a Whipple ocular micrometer in one ocular of a binocular microscope and the use of an oil-immersion lens (1.8-mm. objective, or magnification of 95 times). This, combined with a 10 times ocular with a tube length of 160 mm., provided a total magnification of 950 times. The micrometer squares the field and divides it into 100 smaller squares. The Whipple ocular micrometer was calibrated by means of a Leitz stage micrometer. A 1.8-mm. objective with a magnification of 95 times was employed; with this objective the Whip-

ple micrometer covered exactly 10 of the 1/100-mm. lines. One side of the micrometer was 0.1 mm. or 100 microns in measurement, which gives an area of 0.01 sq. mm. for the large square of the ocular micrometer. By means of a smoothly working mechanical stage, axis of movement of which coincided with the lines in the micrometer, the section was explored systematically and accurately, so that the entire surface was completely covered. Fractional fields were added to the whole fields, and the number of fibers per individual field was recorded. The addition of the whole and the average of the fractional fields were calculated to give the cross-section area of any given nerve in terms of micrometer fields, and then the results were translated into square millimeters.

The nuclei were sectioned serially at 10 microns and every tenth section was mounted. Cresyl-violet stain was used. The cells with their Nissl bodies showed up clearly and characteristically. Under the low-power objective the nuclei were outlined by means of India ink to guard against any loss of field under higher magnification. The cells within the obvious limits of each nucleus were studied under the high-dry lens. In counting the cells of the fourth and sixth nuclei, the high-dry lens was used, so that a total magnification of 430 times was achieved.

Only typical motor nerve cells were counted. This was accomplished by enumeration of only the cells which had a clearcut nucleolus, so as to obviate any error due to inclusion of fractional parts of a nerve cell. All the cells in each section were enumerated and since each tenth section was so studied, the sum of the number of cells determined in this way was multiplied by the factor 10 to obtain the estimate of the total number of cells in the nucleus.

TABLE 2

NUMBER OF CELLS IN NUCLEUS AND NUMBER OF FIBERS IN NERVE

Cranial Nerve	Cases	Cells of Nucleus		Fibers of Nerve*	
		Mean	S.D.‡	Mean	S.D.
4th					
Right	23	2,400 ± 94†	452	2,187 ± 81†	388
Left	24	2,366 ± 90	438	2,107 ± 76	372
6th					
Right	23	6,137 ± 295	1,416	5,070 ± 196	942
Left	24	6,171 ± 265	1,297	5,281 ± 236	1,155

* Proximal portion of nerve, Bodian technique.
† The numbers after the ± are the standard errors of the means.
‡ Standard deviation.

RESULTS

Concerning the relationship of the number of cells and fibers to age, body length, and to each other, only the enumerations of cells and fibers were utilized in the cases in which both were available; that is, in such instances as those in which an enumeration of the fibers was made but not of the number of the cells of the corresponding nucleus, both enumerations were omitted; and similarly, when the number of cells but not the number of fibers was obtained, both factors were discarded. In all comparisons of cell counts with nerve-fiber counts I shall consider only those nerves which were sectioned proximally and stained by the Bodian (silver) technique, so that the

reader may be reasonably sure that all fibers (myelinated and unmyelinated) were included and that they were from the central nervous system, since sympathetic or other fibers might enter the nerve trunk in its more peripheral region.

The mean number of cells and the variability measured in standard deviation was determined for the fourth and sixth cranial nerves on the right and left sides separately, and similarly, for the number of fibers. These results are shown in table 2. In the enumerations given for the number of fibers in this table, those obtained from the proximal section of the nerves stained with the Bodian technique are the ones which are referred to. The difference between the enumerations for the right and left sides for the fourth and sixth nerves, so far as the nucleus and fibers are concerned, is not statistically significant.

The variability from individual to individual shown in the tables as standard deviations indicates broadly the same relationships as those just outlined for the means. That is, there is no important difference indicated as between the right or left side, but the sixth cranial nerve shows a larger absolute variability than the fourth cranial nerve. The average variability measured relatively as the percentile coefficient of variation (standard deviation divided by the mean times 100) is about 19 percent for the nucleus of the fourth cranial nerve and about 22 percent for the sixth cranial nerve, so that the interindividual variability is about the same for the fourth and sixth cranial nerves in so far as the nucleus is concerned. The same relationship of interindividual variability obtains for the nerve fibers, the coefficient of variation being 18 to 20 percent for both nerves studied.

TABLE 3

DIFFERENCE BETWEEN AND RATIO OF CELLS AND FIBERS

Cranial Nerve	Cases	Difference Between Cells and Fibers		Ratio of Cells to Fibers	
		Mean	S.D.	Mean	S.D.
4th					
Right	23	212 ± 78	372	1.11 ± 0.04	0.18
Left	24	260 ± 85	415	1.15 ± 0.05	0.24
6th					
Right	23	1,068 ± 180	847	1.21 ± 0.03	0.17
Left	24	890 ± 211	1,035	1.19 ± 0.04	0.22

The relationship of cells to fibers was studied in regard to: (1) the difference in absolute numbers, (2) the ratio of cells to fibers, and (3) the regression of cells on fibers.

Quantitative differences between cells and fibers. In the majority of cases there were more cells than fibers, so that in these cases the difference was positive and the ratio was more than 1 to 1. For the fourth cranial nerve and nucleus, out of the 47 observations, there were 12 instances, or 25 percent, in which the enumerations indicated fewer cells than fibers. For the sixth cranial nerve, out of the 47 cases studied, the observed number of cells was less than the number of fibers in only two instances.

The means of the differences are equal for the right and the left sides for both nerves studied, within statistically significant limits. For the right fourth-cranial nerve complex, the mean difference was

212, in terms of excess of cells over fibers, and for the left side it was 260 (table 3). For the right sixth cranial nerve the mean difference as enumerated was 1,068, in terms of excess of cells over fibers. On the left side it was 890. The difference between the right and left side of the sixth cranial nerve in regard to number of fibers also may be considered in terms of the ratio of the number of cells to the number of fibers; that is, the cell-fiber ratio. Obviously, if the difference, cells minus fibers, is positive, the cell-fiber ratio is greater than 1 to 1. The mean for the cell-fiber ratios for the fourth cranial nerve was 1.11 on the

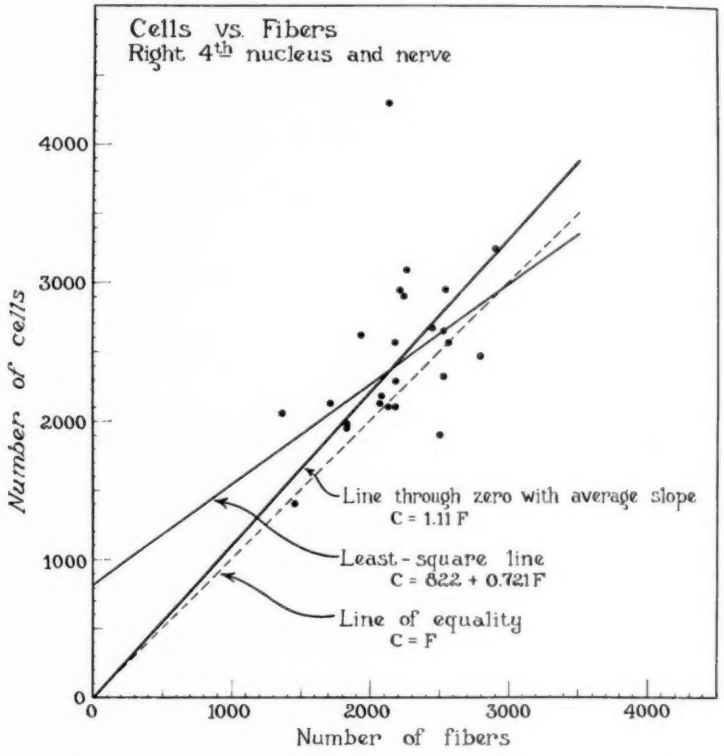


Fig. 1 (Harley). Cells as compared to fibers: right fourth nucleus and nerve.

excess of cells over fibers, namely 178 cells, is not statistically significant in the light of the errors of estimates themselves. However, in all instances the mean differences were significantly different from zero. This is to say that it was found in the enumerations made that there was an excess of cells over fibers for both nerves and on each side, and that the differences were statistically significant.

The ratio of cells to fibers. The difference between the number of cells and the right side and 1.15 on the left.* The difference between these two values, namely, 0.04, is statistically insignificant

* The mean of the ratios obtained from the individual cases will be in general numerically different from the value obtained by computing the ratio of the mean number of cells to the mean number of fibers, but the difference is generally small and not important. If the ratio of the cells ÷ fibers is considered as an entity, it is more proper to get the mean of these values. Moreover, from this viewpoint, the variability of the ratios also can be calculated.

in the light of the errors in each number. For the sixth cranial nerve the mean ratio of cells to fibers was 1.21 on the right side and 1.19 on the left side, the difference of 0.02 being again insignificant statistically. As between the sixth nerve and the fourth nerve, the difference in the ratios of cells to fibers, namely +0.07, indicating a greater excess of cells over sixth cranial nerves and for the right and left sides, separately. It is obvious from inspection that there is a positive regression of cells on fibers; which is to say that in general, as the number of fibers increases in the nerve, so also does the number of cells in the corresponding nucleus. The correlations measured in terms of the product-moment coefficient for the

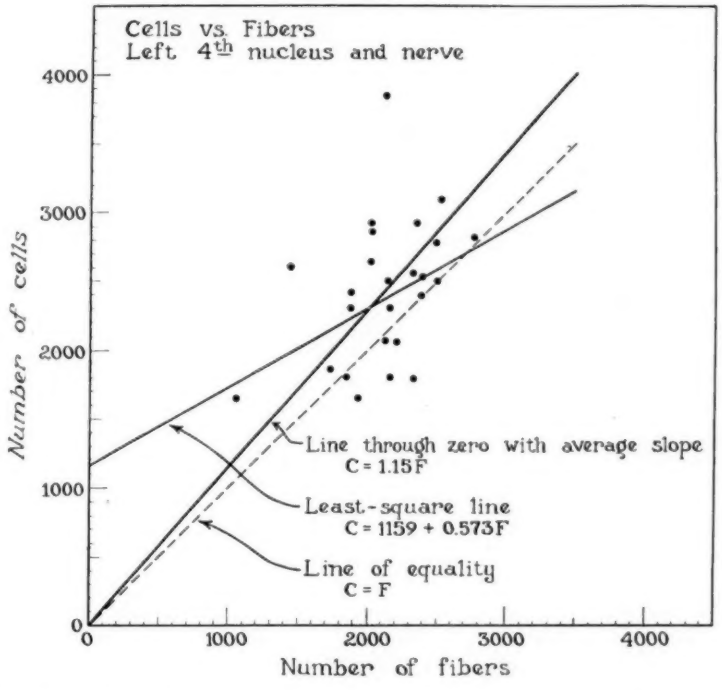


Fig. 2 (Harley). Cells as compared to fibers: left fourth nucleus and nerve.

fibers in the sixth nerve than in the fourth nerve, although not large, is statistically significant. That is, it may be said with considerable confidence that so far as the enumerations made in this study are concerned, the excess of cells over fibers of the sixth cranial nerve is greater than the excess existing for the fourth cranial nerve.

Regression of cells on fibers. In figures 1 to 4 the number of cells is plotted against the number of fibers for each observation made, for the fourth and fourth and sixth cranial nerves on the right and left sides, respectively, are +0.62, +0.49, +0.82, and +0.65. Since however, the distribution for the cell counts themselves and the fiber counts are not Gaussian, the correlation coefficients as such are not very appropriate, and it is better to consider the relationship in terms of regression lines.

In each of the figures will be found three lines. One is the line of equality which the points would follow if fibers and cells were substantially equal in

general. Most of the points are found to lie above the line of equality. This is in accord with what has already been mentioned herein; namely, that in most instances the cells were more numerous than the fibers. A second line represents the regression utilizing the average ratio. This is a line drawn through zero and having as its slope the average ratio as previously determined (table 3). If, in general, the cells were greater than the fibers in some fixed ratio, the points would follow such a line as this. The third line is the regression line for cells on fibers obtained by the method of least squares. In all but one (the sixth cranial nerve on the right side) the lines as they were obtained by this method did not actually go through zero. For these lines, therefore, the ratio of cells to fibers is not number constant, decreasing with increasing number of cells or fibers in the nucleus-nerve complex. However, the question arises as to whether the intercept of lines on the axis of cells is significantly different from zero, which is another way of asking whether the fact that the least-square lines do not go through zero (making the cell-fiber ratio inconstant) is attributable to the random error of the points. Considering the variability evident in the points, it is reasonable to attribute these differences as found to random variation, and therefore a return is made to the summary statement that the relationship of the cells to fibers is satisfactorily represented by the line of average ratio.

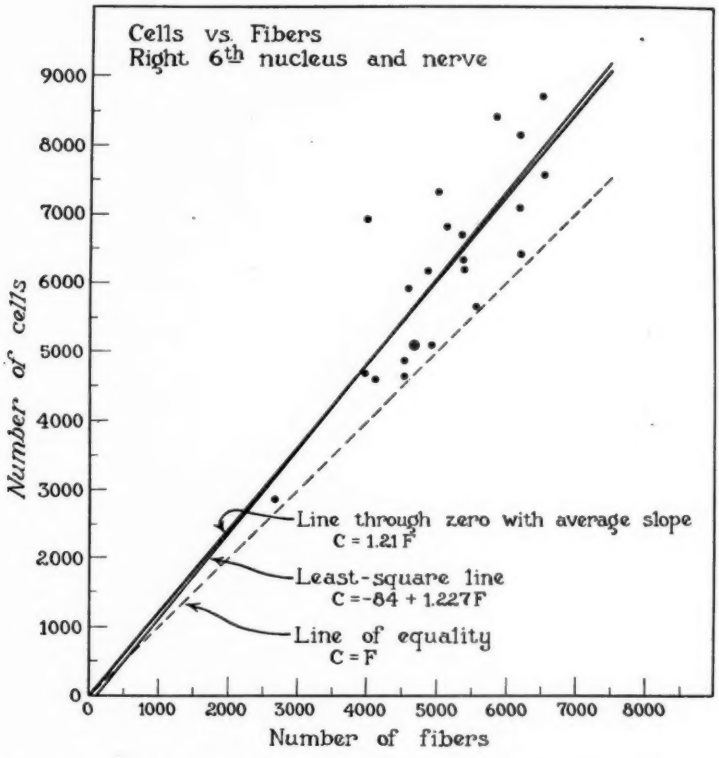


Fig. 3 (Harley). Cells as compared to fibers: right sixth nucleus and nerve.

Some interest has been expressed regarding the question as to whether the

number of cells or fibers is affected significantly by age or body size. Although this was not the main purpose of the present study, the available data permitted some examination of this question. The relationship between these factors was studied statistically in terms of the correlation coefficient and regression coefficient between the factors involved, and these are shown in table 4. The correlation coefficient (r) is a measure of the degree of association between the factors studied, and the regression coefficient (b) gives the change in one factor per unit change in the other factor. If there is no relationship between the variables studied, these measures, r and b, will be close to zero. The table shows that age has little or no relationship to the number of cells and fibers. Body length has a small but rather definite relationship to the number of cells and fibers, indicating that larger persons as measured by the body length tend to have nucleus-nerve complexes containing more cell and fiber elements than do smaller persons. It should be realized that the number of cases available for the study of these relationships is small, and that, as indicated by the comparatively large relative size of the standard errors, only tendential relationships can be indicated.

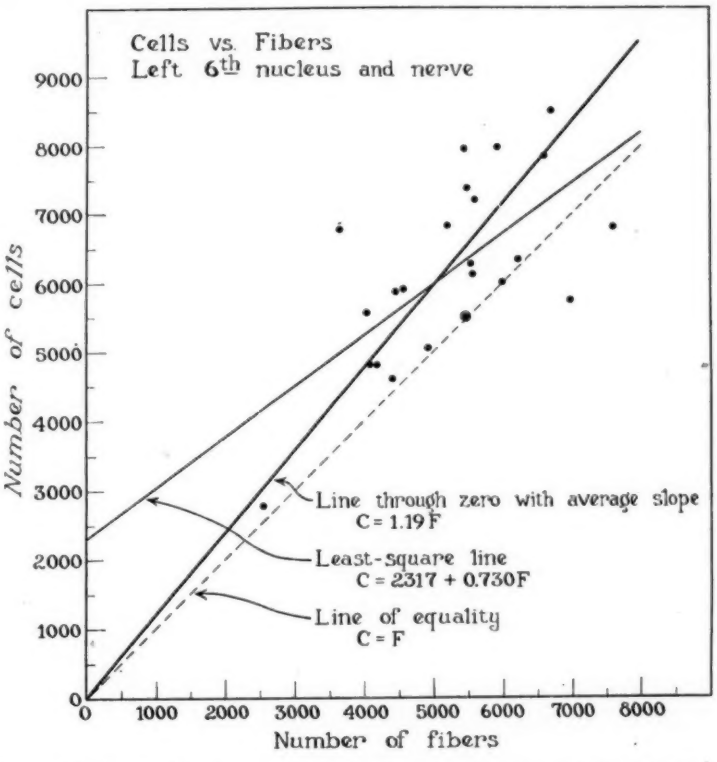


Fig. 4 (Harley). Cells as compared to fibers: left sixth nucleus and nerve.

Because of the interest in the number of myelinated fibers in contradistinction to the total number of fibers, in a certain number of instances proximal sections of the nerve were studied for the total number of fibers and also the number of myelinated fibers. Adjacent sections in each nerve were utilized, the total number

TABLE 4

CORRELATION OF CELLS AND FIBERS WITH AGE AND BODY LENGTH

Cranial Nerve	Structure Studied	Status	Cases	Correlation Coefficient r*	Regression Coefficient b*
4th Right	Cells of nucleus	Age	26	0.15±0.20	2.64± 3.52
		Body length	21	0.34±0.22	4.17± 2.70
	Fibers of nerve	Age	25	0.29±0.20	4.18± 2.88
		Body length	19	0.49±0.21	4.87± 2.09
6th Right	Cells of nucleus	Age	24	0.08±0.21	16.35±42.92
		Body length	19	0.17±0.24	29.75±42.00
	Fibers of nerve	Age	23	0.09±0.22	3.85± 9.41
		Body length	18	0.39±0.23	22.89±13.50

* The numbers after the ± are the standard errors of the statistics referred to.[8]

of fibers being obtained by use of the Bodian silver technique, and the number of myelinated fibers being determined by use of azocarmine (Mallory-Heidenhain). In table 5 is given the summary of the observations made in this particular part of the study. It was found that on the average, for the fourth cranial nerve, there was a difference of about 150 between the total and myelinated fibers, indicating that there were approximately that number of unmyelinated fibers. In the sixth cranial nerve the average difference between the total and unmyelinated fibers was about 440 unmyelinated fibers.

In a certain number of cases as to the fourth cranial nerve, an enumeration of the number of fibers was made in which the Bodian technique of staining was utilized, a count being made in a section obtained from the proximal portion of the nerve (10 mm.) and also from a distal portion (25 mm.). In a study of seven cases of the fourth cranial nerve taken from the right side, the mean difference in number of fibers between the distal and proximal portions was 210±84 fibers, and in nine cases of fourth cranial nerve taken from the left side the mean difference was found to be 265±43 fibers. It was found, therefore, as might have been expected, that there were more fibers in

TABLE 5

TOTAL AND MYELINATED FIBERS

Cranial Nerve	Cases	Total Fibers*	Myelinated Fibers†	Difference Between Total Fibers and Myelinated Fibers	
		Mean	Mean	Mean	S.D.‡
4th					
Right	13	2,297	2,132	165±29	104
Left	14	2,061	1,928	133±17	63
6th					
Right	12	4,630	4,250	380±86	285
Left	18	5,534	5,036	498±77	318

* Proximal part of nerve, Bodian staining technique.
† Proximal part of nerve, azo-carmine technique.
‡ Standard deviation.

the distal portion of the nerve.

In table 6 are given, for the fourth and sixth cranial nerves and the right and left sides, separately, for a certain number of cases as indicated, the cross-section area of the nerves and the lengths of the nuclei. As is seen, there is no difference indicated between the right and left sides so far as either the cross section of the nerve or the length of the nucleus is concerned, and as before indicated in the enumeration of cells and fibers, the sixth cranial nerve and nucleus are larger than the corresponding fourth cranial nerve and nucleus.

TABLE 6

CROSS SECTION OF NERVES AND LENGTH OF NUCLEUS

Cranial Nerve	Cases	Cross-sectional Area,* sq. mm.		Cases	Length of Nucleus, mm.	
		Mean	S.D.		Mean	S.D.
4th						
Right	13	0.22±0.02	0.06	27	2.4±0.07	0.38
Left	15	0.22±0.01	0.05	26	2.4±0.07	0.34
6th						
Right	11	0.59±0.05	0.15	24	3.3±0.09	0.42
Left	19	0.55±0.03	0.13	25	3.3±0.08	0.39

* Sections taken at proximal portion of the nerve, azo-carmine stain.

The histologic aspects of some of the sections studied appear in figures 5, 6*a*, *b*, *c*, and *d*, and 7.

SUMMARY AND CONCLUSIONS

An attempt has been made to determine the normal relationship between the number of fibers in the fourth and sixth cranial nerves of man and the number of cells in their respective nuclei.

It was found that the mean number of cells for the nucleus of the fourth nerve was 2,383 and the mean number of fibers was 2,147. For the sixth cranial nerve the mean number of cells of the nucleus was found to be 6,154, and the mean number of fibers, 5,176. No significant difference was found as between the right and left sides in respect to both the number of cells and the number of fibers.

The number of cells in the nuclei was found to exceed the number of fibers in the corresponding nerve in almost all instances. The mean differences of cells minus fibers for the fourth cranial nerve on the right and left sides and the sixth cranial nerves on the right and left sides, respectively, were 212, 260, 1,068, and 890. All these differences were statistically significant. The cell-fiber ratios were also studied and the mean values for the same four nucleus-nerve com-

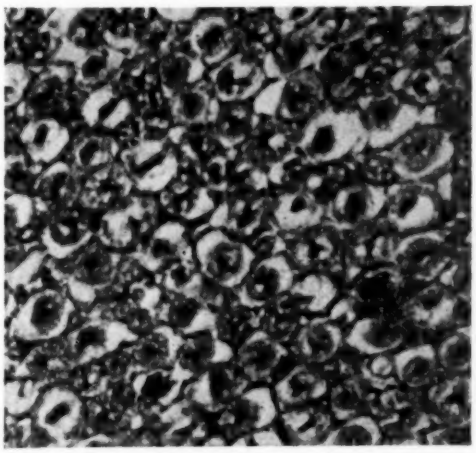


Fig. 5 (Harley). Fourth nerve (Mallory-Heidenhain ×800, oil immersion).

plexes were 1.11, 1.15, 1.21, and 1.19. The excess of cells over fibers averaged about 13 percent for the fourth cranial nerve and about 20 percent for the sixth cranial nerve; and the difference of 7 percent indicated a greater excess of cells found that larger persons have nucleus-nerve complexes containing more cell and fiber elements than small persons have.

An enumeration of the number of fibers in the distal versus the proximal portion of the nerve indicated an average

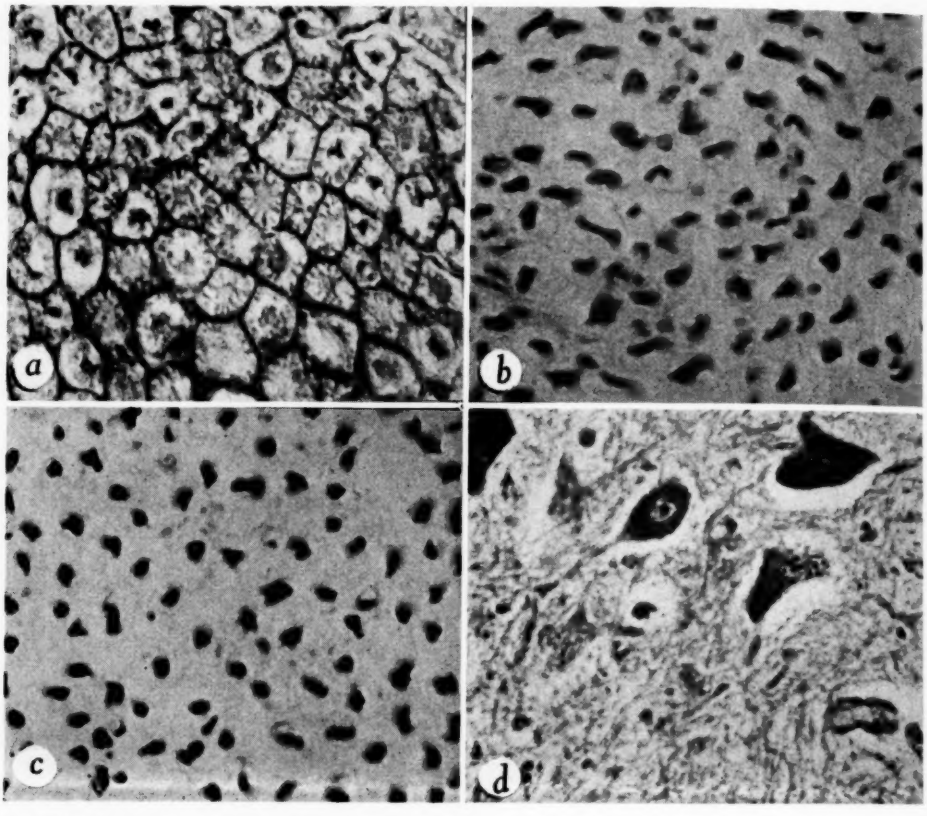


Fig. 6 (Harley). *a*, Sixth nerve (Mallory-Heidenhain ×800, oil immersion); *b*, sixth nerve (Bodian ×800, oil immersion); *c*, fourth nerve (Bodian ×800, oil immersion); *d*, fourth nucleus, ×350.

over fibers in the sixth nucleus-nerve complex as compared to the fourth.

The relationship of cells to fibers also was studied graphically and with the aid of fitted regression lines, which are shown in figures 1 to 4 of the text.

The relationships of the number of cells and fibers to age and to body length were studied, and the correlation and regression coefficients for each of the combinations were calculated. Some evidence was

increase of 238 in the number of fibers in the case of the fourth cranial nerve.

The number of unmyelinated fibers as determined by the difference between the total number of fibers and the number of myelinated fibers was 150 for the fourth cranial nerve and 440 for the sixth cranial nerve. The average length of the nucleus for the fourth nerve was 2.4 mm., and for the sixth nerve, 3.3 mm.; and the mean cross-sectional areas for the corre-

sponding nerves, respectively, were 0.22 and 0.59 sq. mm.

The fourth and sixth cranial nerves belong to the type of mixed nerve, whose afferent fibers convey pain and the proprioceptive sense. Björkman and Wohlfart[1] made careful measurements of the fiber diameter in one fourth cranial nerve and one sixth cranial nerve. If it is assumed, on the basis of the work of Zotterman,[11] that pain fibers alone range in size from about 4 microns and less in diameter, then on the basis of the work of the aforementioned authors it may be reasonably estimated that in the fourth cranial nerve at least 39 percent are sensory and 61 percent are motor, and in the sixth nerve at least 22 percent are sensory and 78 percent are motor. These figures probably do not represent the total number of sensory fibers present, since the proprioceptive fibers do not enter into this class. Since I found for the fourth cranial nerve an average ratio of cells to total fibers of 1.13, applying the correction of 61 percent for motor nerves, I would estimate that the ratio of cells to motor fibers is 1.85 (1.13 ÷ 0.61), which is to say that it is indicated that there are about 85 percent more cells than motor fibers in the fourth nucleus-nerve complex. For the sixth cranial nerve, similarly, I found an average ratio of cells to total fibers of 1.20 and, applying a correction of 78 percent for motor fibers, I would estimate the ratio of cells to motor fibers as 1.54 (1.2 ÷ 0.78), which is to say that there are slightly more than 50 percent more cells than fibers in the sixth nucleus-nerve complex.

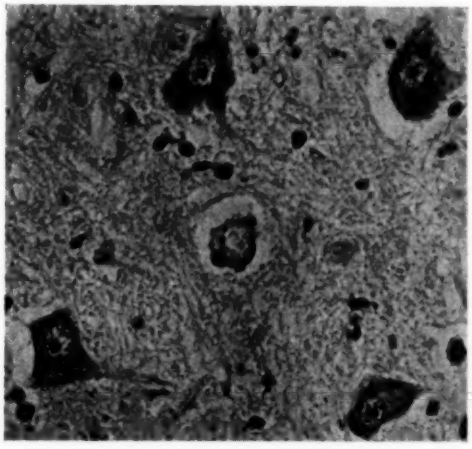


Fig. 7 (Harley). Sixth nucleus, ×350.

Since there are clearly more cells in the so-called nuclei than motor fibers in the peripheral nerves, it is logical to assume that the motor nuclei of the fourth and sixth cranial nerves send fibers not only peripherally into these nerves, but centrally to other regions, such as to other cranial nuclei, probably via the median longitudinal fasciculus. Some of the association mechanism (association centers) may thus be within the confines of the so-called nuclei of the ocular nerves.

References

[1] Björkman, A., and Wohlfart, G. Faseranalyse der Nn. oculomotorius, trochlearis und abducens des Menschen und des N. abducens verschiedener Tiere. Zeit. f. mikr.-anat. Forsch., 1936, v. 39, pp. 631-647.

[2] Bors, Ernst. Ueber das Zahlenverhältnis zwischen Nerven und Muskelfasern. Anat. Anz., 1926, v. 60, Jan., pp. 415-416.

[3] Chiba, M. Die Abstufbarkeit der Seitwärtswendung des Auges und die Zahl der Fasern im N. abducens. Arch. f. d. ges. Physiol., 1926, v. 212, pp. 150-157.

[4] Krause, W. Handbuch der menschlichen Anatomie. Hannover, 1876, v. 1, p 472.

[5] Maleci, O. Contributo alla conoscenza delle variazioni quantitative delle cellule nervose nella senescenza. Arch. di ital. anat. e di embriol., 1934, v. 33, pp. 883-901.

[6] ———. Sul rapporto numerico tra le cellule dei nuclei di origine e le fibre di nervi motori encefalici dell' uomo, con osservazioni sulle differenze qualitative delle dette fibre. Arch. ital. di anat. e di embriol., 1936, v. 35, pp. 559-583.

[7] Merkel, F. S. Makroskopische Anatomie des Auges. Graefe-Sämisch's Handbuch für Augenheilkunde. Leipzig, 1874, v. 1, pp. 1-168.
[8] Pearl, Raymond. Introduction to medical biometry and statistics. Ed. 3, Philadelphia, W. B. Saunders Company, 1940, 537 pp.
[9] Rosenthal, H. De numero atque mensura microscopica fibrillarum elementarium systematis cerebro-spinalis symbolae. Dissertatio. Vratislaviae, 1845, p. 1.
[10] Tergast, P. Ueber das Verhältniss von Nerve und Muskel. Arch. f. mikr. Anat., 1873, v. 9, pp. 36-46.
[11] Zotterman, Yngue. A note on the relation between conduction rate and fiber size in mammalian nerves. Skandinav. Arch. f. Physiol., 1937, v. 77, pp. 123-128.

Discussion

Dr. H. J. Smith (Chicago): Mr. Chairman: Referring to the lack of correspondence between the number of cell bodies and number of efferent fibers in the fourth nerve, may I suggest that some of these cell bodies may have axones crossing to the nucleus of the opposite side, as has been shown to be the case in the nuclei of the third nerve. I do not have any information bearing upon the sixth nerve and do not know whether a similar decussation occurs there, but think it extremely possible that it does exist in the fourth nerve.

Dr. Benedict: I think that Dr. Harley did not assume terminal association. His work had to do with the actual count. On the other hand, the deviation, the individual variability between the right and the left side, was statistically insignificant, and there appeared to be nearly equal excess of cells over fibers on both the right and the left side, so it is quite possible that there was a direct relationship, although that is purely an assumption. How many of the fibers might go to the nucleus of the third-nerve or the sixth-nerve nucleus, or whether they would go to some other nucleus is not known, but it is presumed that certainly there is a sufficient excess of cells over fibers for that to be possible.

In going over some of the specimens he felt that probably some of those nuclei were idle and that they had no connection with any other source. At any rate, he was not able to trace, except in myelinated fibers, any other group of fibers to these cells. They simply exist there, but he was not able to determine what connection they have.

Dr. Frederick H. Verhoeff (Boston): Is it not possible that the excess of cells in the nuclei may be due to the fact that many of the cells may not have processes? In other words, we can't draw any conclusion from this finding?

Dr. Benedict: No.

Dr. Verhoeff: You spoke of proprioceptor fibers. The evidence is that there is no proprioceptive sense for the ocular muscles. The work that was done by Ludvigh and Irvine indicated very clearly that the old idea was true that the knowledge of position of the eye was not dependent on a proprioceptive sense. Therefore, you don't have to consider proprioceptor fibers in this connection at all.

Dr. Benedict: It is assumed that those fibers that were not myelinated motor fibers were sensory, but he did not say whether they were proprioceptive or not.

CORNEAL PERMEABILITY*

I. Factors affecting penetration of drugs into the cornea

Kenneth C. Swan, M.D., and Norman G. White, M.S.
Iowa City, Iowa

Passage of drugs through the cornea into the globe is generally considered to be a process of diffusion.[1] The rate of diffusion is believed to be affected by variations in osmotic pressure,[2, 3] pH,[4] and concentration of the test solution,[5] as well as by intraocular pressure[6] and the condition of the surface epithelium.[7] The epithelium is considered to act as a barrier limiting the passage of water and other substances into the cornea.[1, 8] Consequently, disturbances of the surface epithelium are thought to increase corneal permeability to all drugs.

However, several factors affecting permeability have not received consideration. The influence of molecular structure and physical properties of compounds has not been investigated, although it has been assumed that relative permeability of the cornea to drugs is in inverse relation to the size of the individual molecules.[9] Studies on other tissues indicate that molecular structure, with particular regard to the relationship between nonpolar and polar† groups, has a profound effect on penetration, while molecular size is of less importance.[10, 11, 12] In general predominantly polar compounds enter cells less rapidly than do nonpolar substances.

The influence of polar and nonpolar structure on cell penetration seems to be related to the changes produced in the physical properties of compounds, particularly surface activity and solubility in water and lipoids. The recent use by O'Brien and Swan[13] of a surface-tension-reducing agent to increase absorption of doryl suggests that at least one of these physical properties of compounds affects corneal permeability. In addition, these authors suggested that the relative impermeability of the epithelium to doryl may be explained by the fact that this compound is highly polar.

To study and correlate these possible new factors with older concepts required investigation of the entire problem of corneal permeability. First, factors affecting the rate of penetration of drugs into the cornea were studied, especially with reference to the permeability characteristics of the normal epithelium as compared to the stroma. Other phases of corneal permeability will be considered in subsequent reports.

Experimental

Polar and nonpolar compounds

In the first series of experiments, comparative rates of penetration into the cornea of polar and nonpolar compounds were determined. Amine and sulfonic-acid derivatives of naphthalene were selected as test substances (fig. 1). Naphthalene was nonpolar; consequently, highly soluble in

* From the Department of Ophthalmology, College of Medicine, State University of Iowa. Part of a study being conducted under a grant from the John and Mary R. Markle Foundation. Read at the thirteenth scientific meeting of The Association for Research in Ophthalmology, at Atlantic City, June 9, 1942.

† The outstanding physical property of polar molecules, or compounds in which polar radicals predominate, is a high degree of solubility in water. Water is polar as are many inorganic electrolytes. Carboxyl, hydroxyl, amine, sulfonic, and similar "hydrophilic" radicles are examples of polar groups which may be attached to organic molecules. In contrast, nonpolar compounds are characteristically more soluble in organic solvents than in water and are spoken of as "hydrophobic." The hydrocarbons are examples.

lipoids and insoluble in water. When polar groups (amine and sulfonic acid) were attached to naphthalene, the water solubility was increased and lipoid solubility decreased. To control the influence of electric charges, both basic (amine) and acid (sulfonic) polar groups were added.

aqueous and anterior sclera. After three minutes, unabsorbed test solution was washed from the corneal surface with normal saline solution and the cornea was then rapidly excised and weighed. The test substances were extracted with water and varying dilutions of ethyl alcohol. Analysis presented no problem, since the

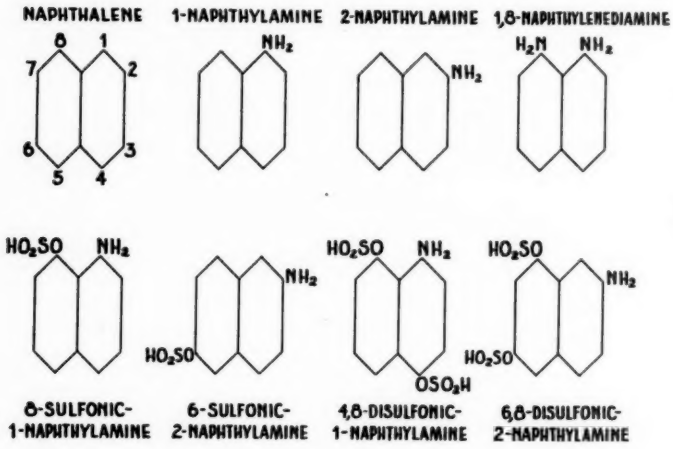


Fig. 1 (Swan and White). Molecular formulas of naphthalene derivatives studied.

All test solutions were buffered to pH 7.0 and were made isotonic with 1-percent sodium chloride by the addition of this salt.* Temperature of solutions was maintained at 35°C. To minimize possible toxic or irritating effects of the test substances on the corneal epithelium, dilute solutions were used.

The experiments were made on living albino rabbits under general anesthesia (ether, urethane, or nembutal). The lids and nictitating membranes were retracted and the test solutions were administered without trauma in a continuous gentle stream over the cornea. The solutions were allowed to flow over the cornea for only three minutes since longer periods permitted passage of portions of the test substance from the cornea into the test substances were dye intermediates and could be coupled with other dye intermediates to form azo dyes, suitable for analysis by colorimetric methods.[14, 15] Concentrations of approximately 1 mg. percent required a single cornea for analysis; but in most experiments the concentrations were larger, thus allowing bisection of the cornea with extraction and analysis in duplicate. Comparison of these duplicate determinations revealed that the experimental error was slightly less than 12 percent.

The results as shown in table 1 indicate that naphthalene compounds with only one polar amine group readily penetrated into the cornea. With the addition of a second polar amine group, penetration was only one third as rapid. If, instead of the second amine, a sulfonic-acid group was added, the rate of penetration was reduced to an even greater extent. The relative position of the sulfonic-acid and

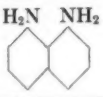
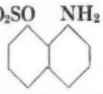
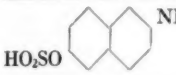
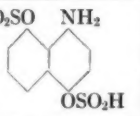
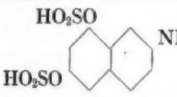
* Hydrogen-ion measurements were made with a glass electrode and the osmotic-pressure measurements were made by the vapor-pressure method.

amine groups seemed to have some effect. The compound in which the sulfonic-acid and amine groups were in adjacent positions on the naphthalene nucleus penetrated more rapidly than the compound in which these groups were at opposite ends of the nucleus. Finally, the molecules with two polar sulfonic-acid groups and one polar amine group penetrated one fiftieth as rapidly as the compounds with only a single polar radicle.

Decrease in penetration with each addition of a polar group was possibly due in part to the increase in molecular weight and size. If penetration into the cornea was a simple diffusion process, as has been assumed in the past, relative molecular weight and size would be important factors. To investigate this possibility, the relative polarity of the one test substance was increased and the molecular size decreased by reducing the size of the nonpolar nucleus. The single-ring phenyl nucleus was substituted for the double-ring naphthalene nucleus (fig. 2). As shown in table 2, the rate of penetration of monosulfonic phenylamine into the intact cornea was less than that of the related naphthalene derivatives, although the molecule was smaller. This did not

TABLE 1

EFFECT OF POLAR GROUPS ON THE PENETRATION RATE OF NAPHTHYLAMINES INTO THE NORMAL CORNEA

Test Substance	Molecular Weight	Number of Polar Groups	Number of Eyes Studied	Concentration of Test Solution mg. percent	Average Concentration in Intact Cornea in 3 Minutes mg. percent	Relative Penetration Rates
	143.08	1	7	25	21.45	100.0
	143.08	1	5	25	18.31	85.5
	158.09	2	6	25	6.30	29.4
	241.45	2	5	25	1.24	5.9
	241.15	2	5	25	0.91	4.2
	303.2	3	6	50	0.90	2.1
	303.2	3	8	50	0.70	1.6

necessarily rule out molecular weight and size as factors affecting penetration but rather indicated that other properties such as polar and nonpolar structures were of greater importance. It was concluded that polar and nonpolar structures profoundly affected penetration of drugs into the cornea.

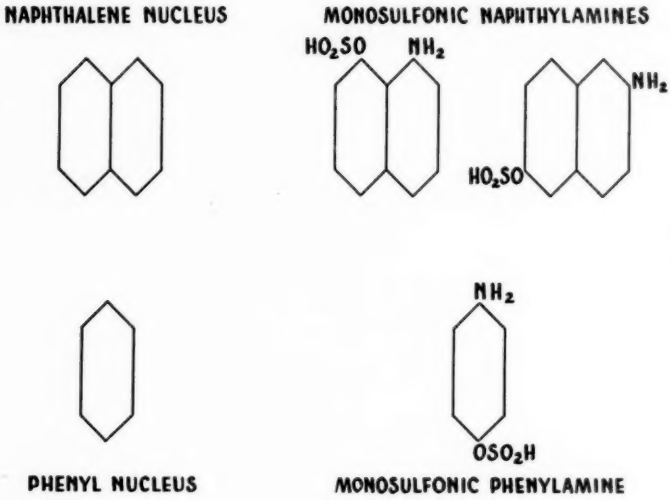


Fig. 2 (Swan and White). Molecular formulas of related phenyl and naphthalene derivatives.

Comparative solubility in water and lipoids was the only physical property of the various compounds that could be correlated with penetration rate. The naphthylamines which were readily soluble in oils and fats and only slightly soluble in water penetrated more rapidly than the sulfonic-acid derivatives which were practically insoluble in oils and fat but were soluble in water.

It was considered that the drug vehicle and the surface of the epithelial cells might be immiscible as are water and fat. If so, the relatively high affinity of the polar compounds for water might result in their retention in the water solution.

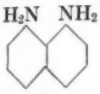
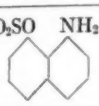
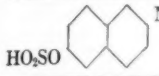
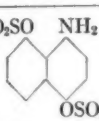
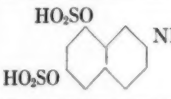
TABLE 2

PENETRATION INTO THE CORNEA OF RELATED PHENYL AND NAPHTHALENE DERIVATIVES

Test Substance	Molecular Weight	Number of Eyes Studied	Concentration of Test Solutions mg. percent	Average Concentration in Cornea in 3 Minutes mg. percent
HO_2SO NH_2	241.15	5	100	1.82
HO_2SO NH_2	241.15	5	100	1.34
NH_2 OSO_2H	191.15	4	100–200	Less than 0.1

TABLE 3

THE PENETRATION OF NAPHTHYLAMINES* INTO THE EXPOSED CORNEAL STROMA

Test Substance	Number of Polar Groups	Number of Eyes Studied	Concentration in Corneal Stroma in 3 Minutes mg. percent	Relative Rates of Penetration
	1	4	14.73	100.0
	1	4	13.44	91.5
	2	4	12.48	85.0
	2	4	11.10	75.5
	2	5	10.40	71.0
	3	4	9.96	68.7
	3	5	6.80	46.2

* 25 mg. percent solutions.

Likewise, highly nonpolar compounds might be retained in oil solutions and enter the cornea slowly. To investigate this possibility studies were made with oil vehicles which have a high affinity for the nonpolar and a low affinity for the polar compounds.

The two predominantly nonpolar compounds (1- and 2-naphthylamine) were dissolved (25-50 mg. percent) in neutral olive oil and run over the cornea for three minutes in the same manner as in the aqueous solutions. Analysis of the corneas of eight experimental animals revealed only faint traces of the test substances, although these compounds had penetrated rapidly from aqueous solution.

In addition, experiments were made with two water-soluble polar compounds suspended in oil. When suspended in oil the predominantly polar disulfonic-acid compounds penetrated 5 to 13 times more readily than did aqueous solutions of equal concentration, although fewer molecules of the test substances actually were in contact with the corneal surface.*

In these comparative studies with oil and water vehicles, affinity of the test substance for the vehicle seemed to affect

* The finest particles in suspension are larger than individual molecules in true solution; consequently particles in suspension have less surface area per unit of weight than do molecules of the same substance in true solution.

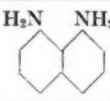
penetration rate of the test substance into the cornea. These data suggested that the partition of the test substance between the cornea and vehicle simulated the distribution of a solute between two immiscible solvents; that is, passage of the drug from the vehicle into the cornea was independent of the concentration gradient and seemed related to solubility of the compound in the vehicle. This distribution was simulated in test-tube experiments. When a small quantity of any of the various compounds was added to a tube containing oil and water, it became distributed unequally in proportion to its relative solubility in the two immiscible solvents.

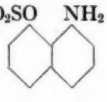
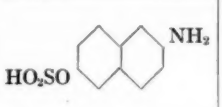
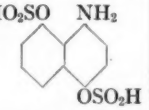
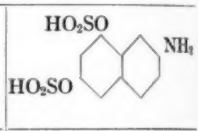
In a second series of experiments, relative permeability of the corneal stroma to polar and nonpolar compounds was investigated. Experiments were exact repetitions of those described above, with the exception that the epithelium of the cornea was removed before the drug solutions were applied. The nonpolar compounds penetrated only slightly better than the polar compounds (table 3). As compared to penetration into the intact cornea (table 4) the rates of the two highly nonpolar naphthylamines were reduced while those of the other compounds were significantly increased. It was concluded that penetration of nonpolar compounds into the epithelium was more rapid and penetration of polar compounds much less rapid than into the stroma. In other words, the epithelium exhibited a higher degree of differential permeability to polar and nonpolar compounds than did the stroma.

It was considered that highly nonpolar compounds might be retained in the epithelium because of their apparent affinity for this structure. To investigate this possibility, the distribution of 2-naphthylamine in the epithelium, stroma, and aqueous was determined. This compound was highly flourescent and its presence in the tissues was determined by biomicroscopy in violet and ultraviolet lights. The tissues were studied after the drug solutions were allowed to flow over the

TABLE 4

RATE OF PENETRATION OF NAPHTHYLAMINES INTO THE EXPOSED STROMA AS COMPARED TO THE INTACT CORNEA

Polar Groups	One Amine		Two Amines
Position of Polar Groups			
Increase or Decrease in Rate	−31.2%	−26.5%	+197%

Polar Groups	One Amine One Sulfonic		One Amine Two Sulfonics	
Position of Polar Groups				
Increase or Decrease in Rate	+900%	+840%	+2200%	+1950%

cornea for varying periods. The test compound was detected in the posterior layers of the stroma within 45 seconds and in the aqueous humor within 2 to 3 minutes. It was concluded that the test substance was not retained in the epithelium but passed readily into the underlying tissues.

In another experiment, the epithelium was scraped from four corneas after the test solution had been applied to the eyes. The epithelium, remainder of the cornea, and aqueous humor were subjected to separate quantitative chemical analyses. The concentration of 2-naphthylamine was found to be higher in the epithelium than in the initial test solution (table 5). The epithelium facilitated rather than diminished penetration of this particular test substance into the cornea. It was concluded, contrary to the accepted concept, that the epithelium of the cornea does not act as a barrier to penetration of all substances. Moreover, as the concentration in the epithelium was greater than that of the initial test solution, the penetration of naphthylamine into the epithelium could not have been by a simple process of diffusion.

TABLE 5

DISTRIBUTION OF NAPHTHYLAMINE,*

, IN THE CORNEA AND AQUEOUS

Tissue		Epithelium	Stroma and Endothelium	Aqueous
Concentration in mg. % (3 minutes)	Range	30.2–67.4	8.04–16.2	Trace—0.2
	Average	42.8	12.20	Trace

* 25 mg.-percent solutions.

SURFACE-ACTIVE COMPOUNDS

It has been known for many years that surface-active compounds penetrate cells more readily than do related molecules that are not surface active. Therefore, penetration through the living cornea of test substances with varying degrees of surface activity was studied.

The surface activity of compounds depends on molecular structure and, therefore, is predictable to a certain extent. Large organic compounds may be predominantly polar at one end of the molecule and predominantly nonpolar at the other end. Molecules with this relationship of nonpolar and polar groups orient themselves at surfaces of water solutions as the polar portions are attracted and the nonpolar repelled by water. As a result such compounds decrease the surface tension at water-air, water-solid, and water-liquid interfaces.

Analysis of the molecular structures (fig. 3) of a group of local anesthetics—pontocaine, butyn, and procaine—indicated that these compounds were particularly suitable for investigation of surface-activity effects on corneal penetration. All were para-aminobenzoic acid esters with amine groups at opposite ends of the molecules. Although the three anesthetics had the same basic structure, changes in the relationship between polar and nonpolar groups changed their surface activity significantly.

In pontocaine, as compared to procaine (fig. 3), the polarity of the amine group at the phenyl end has been decreased by replacement of one hydrogen atom with a nonpolar butyl group. The polarity at the other end of the molecule has been increased by shortening of the nonpolar hydrocarbon chains. As a result, the

pontocaine molecule is predominantly polar at one end and predominantly nonpolar at the other. Pontocaine would be expected to have greater surface activity than procaine.

In butyn (fig. 3) the phenyl end of the molecule remains predominantly polar as in procaine. However, the opposite end of the molecule has been made predominantly nonpolar by addition of several hydrocarbon radicles. As a result butyn would be expected to have greater surface activity than procaine.

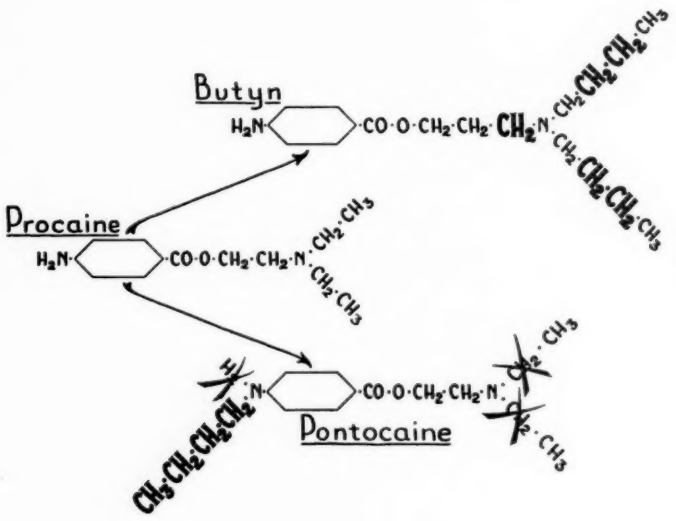


Fig. 3 (Swan and White). Molecular formulas of butyn and pontocaine as compared to procaine.

The effect of procaine, butyn, and pontocaine on the surface tension at water-air interfaces is shown in table 6. These measurements, made by the stalagmometer method, revealed that pontocaine lowered the surface tension markedly, butyn had a limited effect, and procaine was practically inactive. Moreover, pontocaine was rapidly adsorbed from aqueous solutions by Lloyd's reagent (aluminum silicate) and increased the stability of oil-and-water emulsions indicating that it was "active" at water-solid and water-liquid interfaces. Butyn was much less readily adsorbed by Lloyd's reagent, and its effect on oil-and-water emulsions was less also. Procaine was not adsorbed by Lloyd's reagent and had no effect on the formation and stability of emulsions. Therefore pontocaine was highly surface-active, butyn was slightly active, and procaine had no action at all.

TABLE 6

EFFECT OF ANESTHETIC SALTS ON THE SURFACE TENSION OF WATER AT 25°C.

Anesthetic	Concentration of Solution percent	Surface Tension in Dynes per cm.²
Control	Dist. water	72.0
Procaine	2	71.4
Butyn	2	56.2
Pontocaine	0.5	48.8

Other differences in physical properties of these drugs were found to be slight. Butyn was a sulphate salt while pontocaine and procaine were hydrochlorides. However, this difference in anions was not considered significant as osmotic pressure measurements indicated that in dilute solutions (pH 6.4-6.8) the drugs existed almost entirely as free cations. There was little difference in the molecular weight or size of the cations of procaine and

pontocaine but the cation of butyn was larger.

The relative penetration rates of procaine, butyn, and pontocaine salts were studied, using 100 mg. percent solutions. The solutions were buffered to pH 6.8 and made isotonic with 1-percent sodium chloride by addition of this salt. They were administered to intact corneas for three minutes by the same technique and analyzed by the same methods as were the dye intermediates.* Pontocaine penetrated into the intact cornea much more rapidly than did either butyn or procaine, while butyn penetrated about one third faster than procaine (table 7).

These experiments indicated that the surface activity of compounds affected their penetration into the normal cornea as well as into the cells of other tissues.

When the penetration rates of the three anesthetics into the exposed corneal stroma were determined, it was evident

TABLE 7

THE RATE OF PENETRATION OF ANESTHETICS* INTO THE INTACT CORNEA

Anesthetic	Number of Eyes	Average Concentration in Cornea (3 min.) mg. percent	Relative Rates of Penetration
Pontocaine	7	34.01	100
Butyn	5	8.1	23.7
Procaine	26	5.02	14.8

* Aqueous solutions of salts (100 mg. percent).

that the differential permeability of the cornea to their surface-active compounds was dependent upon the integrity of the epithelium. The three anesthetics entered the exposed stroma equally well (table 8). As compared to penetration into the intact cornea, the rates of entrance of procaine and butyn into the exposed stroma were increased while pontocaine penetrated more slowly.

It was concluded from the experiments with the anesthetics that the epithelium had a high degree of differential permeability to compounds dependent upon their surface activity. Moreover, the surface-active pontocaine molecule penetrated more readily into the cornea with intact epithelium than into the exposed stroma; this was further evidence that the epithelium did not act as a simple porous barrier with less permeability to all substances than the stroma.

TABLE 8

PENETRATION OF ANESTHETICS* INTO THE CORNEA BEFORE AND AFTER REMOVAL OF THE EPITHELIUM

Anesthetic	Average Concentration in the Cornea in 3 Minutes	
	Intact Cornea mg. percent	After Removal of the Epitheliun. mg. percent
Pontocaine	34.01	21.20
Butyn	8.10	20.08
Procaine	5.02	24.25

* 100-mg.-percent aqueous solutions of the salts.

PHYSICAL PROPERTIES OF THE DRUG VEHICLES

In another series of experiments, physical properties of the vehicle were varied in order to determine their influence on penetration. Procaine was selected as a test substance because it was easily analyzed and its physical properties and pharmacologic effects were well known.

Hydrogen-ion concentration. There is evidence that the hydrogen-ion concentration of the vehicle may affect the rate of penetration of procaine into the cornea.

* It was difficult to diazotize and couple pontocaine with azo dye intermediates. A quantitative reaction was obtained but it was too insensitive for accurate analysis of a single cornea. Therefore, extractions from several corneas were pooled for analysis.

Gerlough[16] has demonstrated on the rabbit's cornea that as a topical anesthetic procaine is most effective in alkaline solution. He suggested that this increased effectiveness might be due to accelerated penetration. Therefore, the rate of penetration of procaine hydrochloride in solutions of various hydrogen-ion concentrations was determined.

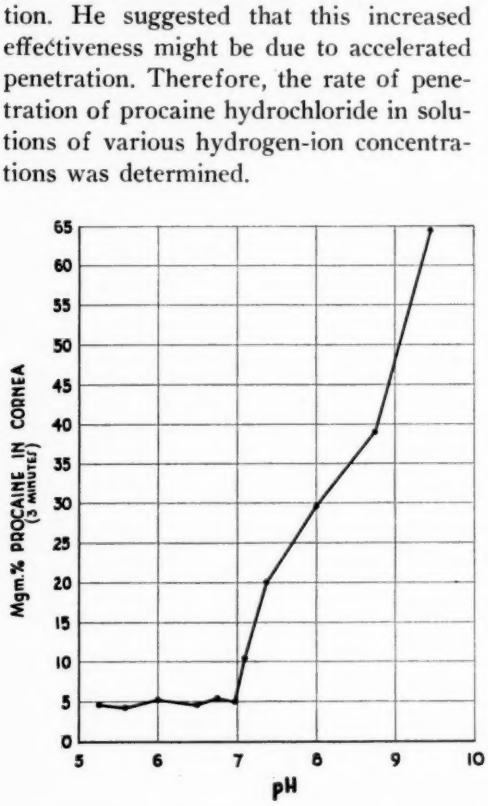


Fig. 4 (Swan and White). The effect of pH of the solution on the penetration rate of procaine into the cornea (100 mg. percent solutions of procaine HCl).

Several types of buffers, dilute hydrochloric acid, and sodium hydroxide were employed to vary the pH. In all other respects, the solutions and experimental methods were the same as described above. The penetration rate of procaine increased with the alkalinity of the test solution (fig. 4); therefore, the increased anesthesia from procaine in alkaline solution could be attributed to accelerated penetration.

The penetration rate of procaine was unchanged in solutions ranging from pH 5.0 to pH 7.0. In these pH ranges procaine hydrochloride in aqueous solutions was almost completely dissociated, consequently its physical properties remained constant. Above pH 7.0, the rate of penetration of procaine increased with the alkalinity of the solution, and in this range the amount of free base increased progressively as the solution became more alkaline.[16] Therefore, the increased penetration rates of procaine in alkaline solutions seemed to parallel conversion of the lipoid insoluble procaine cation to the free lipoid soluble base. To investigate this possibility further, penetration of an 86.63-mg.-percent solution (pH 9.45) of the free base was studied and compared with that of an equi-molecular solution (100 mg. percent) of the procaine salt buffered to the same pH. Dextrose was used to make the solutions isotonic. The rates of penetration of procaine in the two solutions were approximately equal (60.2-68.4 mg. percent). It was concluded that the free base penetrated more readily than the procaine cation and that the increased rate of penetration of procaine hydrochloride in alkaline solution was due to conversion of the slowly penetrating procaine cation to the rapidly penetrating free base. Moreover, it was considered probable that variations in hydrogen-ion concentration would also affect the penetration into the cornea of other compounds whose physical properties were altered by pH changes. Such compounds would include all anesthetics of the procaine group and the alkaloids.

Osmotic pressure. It has been demonstrated by several workers[2, 3] that the osmotic pressure of a vehicle may effect the permeability of the cornea to drugs. However, as the penetration of such drugs as the sodium salts of fluorescein and salicylate was accelerated by both hypotonic and hypertonic solutions, these authors attributed the accelerated pene-

tration to damage to the epithelium rather than to osmotic-pressure imbalances between the intraocular fluids and the drug vehicle.

To determine a suitable agent with which to vary the osmotic pressure of the test solution, preliminary experiments were made with enucleated rabbits' eyes from which the contents had been removed and replaced by 5 percent dextrose in distilled water. The outer surfaces of the corneas were placed in contact with various concentrations of sodium chloride in water. Samples of the intraocular fluids were withdrawn at frequent intervals and tested for chloride by addition of dilute silver nitrate. A white precipitate (silver chloride) appeared when chloride was present. When care was taken to avoid damage to the epithelium either by direct trauma or distortion of the cornea, only traces of chloride passed through the intact cornea in three to five minutes. This finding was in accordance with the studies on naphthalene derivatives. Inorganic electrolytes like chlorides act as polar compounds and would be expected to penetrate the epithelium poorly. Therefore, sodium chloride was considered to be a suitable substance for studies of osmotic effects on the normal cornea.

The penetration rates of procaine hydrochloride in distilled water and various concentrations of sodium chloride were determined. As in other experiments, the eyes of living rabbits were used, and the test solutions were allowed to flow over the cornea in a continuous stream for three minutes. The penetration of procaine from extremely hypotonic solutions was slightly accelerated, whereas the penetration from highly hypertonic solutions was reduced (fig. 5). The latter finding was not necessarily contrary to the observations of previous reports, since, in our experiments, the period of contact of the hypertonic solutions with the cornea was relatively short. When the cornea had been irrigated with a 7-percent sodium-chloride solution for longer than 3 minutes (10 to 25 minutes), penetration of procaine was increased 50 to 75 percent. These corneas showed evidence of epithelial damage, examination with the biomicroscope revealing multiple tiny gray superficial lesions.

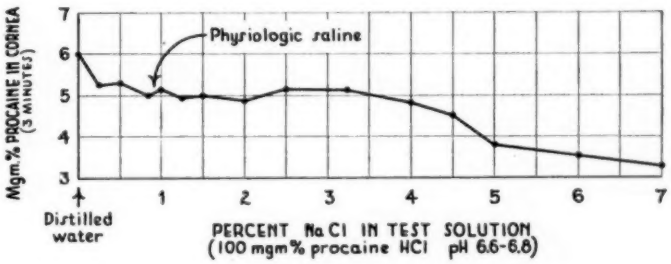


Fig. 5 (Swan and White). The effect of osmotic pressure variations on the penetration of procaine into the cornea.

It was concluded that the action of hypertonic sodium-chloride solutions on the intact cornea could be divided into two phases. Strong hypertonic solutions temporarily reduced penetration of the test substance from the vehicle into the cornea. More prolonged contact resulted in epithelial damage and increased penetration. Markedly hypotonic solutions penetrated at a slightly greater rate than a solution approximately isotonic with the conjunctival secretions. Moderate variations in the osmotic pressure of the vehicle had no effect.

Concentration of the drug solution. In simple diffusion processes, the diffusion

rate varies directly with the concentration gradient. Evidence is lacking that the penetration of drugs into the cornea bears such a relationship to the concentration of the test solution, although it is assumed[1] to be a diffusion process. Therefore, the relationship between concentration of procaine in the vehicle and rate of penetration of the drug into the cornea was studied in 38 eyes. Buffered, osmotically controlled solutions were used and administered as in previous experiments, except that the concentration of procaine was varied. The rate of penetration of procaine did not increase proportionally with concentration (fig. 6) or even approximate such a relationship. It was concluded that the penetration of procaine into the cornea could not be by a simple process of diffusion.

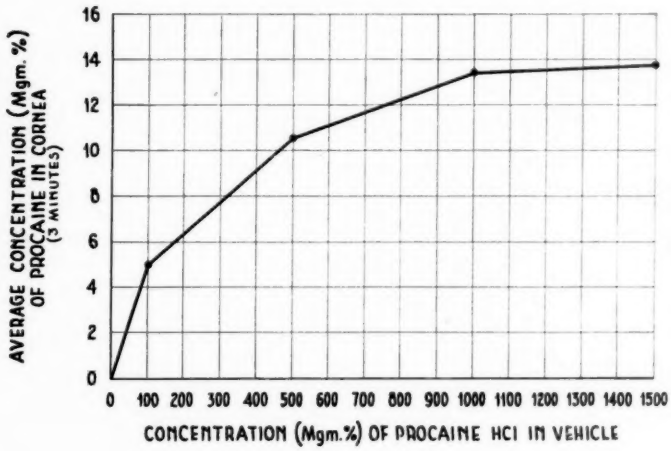


Fig. 6 (Swan and White). Relationship between concentration of the solution and corneal penetration of procaine.

Surface-tension-reducing agents. There is evidence that the presence of a surface-tension-reducing agent in the vehicle may affect penetration of drugs into the cornea. O'Brien and Swan[13] reported that zephiran increased penetration of doryl into the eye from aqueous solutions. It was considered that zephiran might increase penetration of procaine into the cornea, as this drug (in acid solution) has physical properties similar to those of doryl. Both are relatively polar, surface-inactive compounds which penetrate slowly into the normal cornea from aqueous solutions. As in previous studies, 100-mg.-

TABLE 9

THE EFFECT OF ZEPHIRAN ON THE PENETRATION OF PROCAINE* INTO THE CORNEA

Vehicle	Surface Tension in Dynes/ per cm.² 25°C.	No. of Corneas	Average Concentration of Procaine (Base) in Corneas (3 minutes) mg. percent	Relative Penetration Rate
Isotonic Saline pH 6.6	72	26	5.02	1.00
0.03% Zephiran in Isotonic Saline pH 6.8	42	4	9.01	1.78

* 100-mg.-percent procaine hydrochloride in aqueous solution.

percent solutions of procaine hydrochloride made isotonic with 1-percent sodium chloride were administered to the cornea for three minutes. As shown in table 9, the penetration of procaine hydrochloride was accelerated significantly.

INTRAOCULAR PRESSURE

It has been considered that drugs penetrate the cornea more readily when the intraocular pressure is low and less readily when the intraocular pressure is high. Therefore, experiments were made to determine the effect of variations in the intraocular pressure on the penetration of procaine hydrochloride into the cornea.

As in previous studies a procaine-hydrochloride (100 mg.-percent) solution was allowed to run across the cornea for three minutes prior to analysis of the drug in the cornea. The intraocular pressure was varied through a manometer system. To avoid trauma to the conjunctiva and cornea in introduction of the needle, the posterior sclera was exposed by an incision through the upper lid, and a curved needle with a long sharp bevel was slid obliquely through the sclera. Care was taken to minimize distortion of the globe. The needle was connected with a manometer by tubes containing physiologic saline. The intraocular pressure was varied the equivalent of from 8 to 32 mm. of mercury by raising and lowering the level of fluid in the manometer. In this pressure range there was no significant change in the rate of penetration of procaine into the cornea if distortion of the globe was avoided. At higher or lower pressures penetration often was considerably increased. However, distortion of the globe could not be controlled as was evidenced by the flattening of the cornea under high tensions and the appearance of folds in the corneas under very low tensions. As the increases in penetration rate seemed proportional to the distortion of the globe and occurred at both high and low tensions, it was considered that these increases were due to mechanical damage to the epithelium. It was concluded that acute variations in intraocular pressure did not affect the rate of penetration of procaine into the cornea except indirectly by damage to the epithelium.

TABLE 10

EFFECT OF VARIATIONS IN INTRAOCULAR TENSION ON THE RATE OF PENETRATION OF PROCAINE* INTO THE CORNEA

Intraocular Pressure mm. Hg	Number of Eyes	Concentration of Procaine in Cornea in mg. percent	
		Range	Average
8–15	5	4.2–6.4	5.21
18–23	4	4.4–6.2	5.72
27–32	6	3.8–6.9	5.12

* 100-mg.-percent procaine hydrochloride in saline solution.

DISCUSSION

The studies herein reported indicate that penetration of all drugs into the cornea is not a simple matter of diffusion, as has been assumed for many years. Rather, it is a complex process affected by multiple interrelated factors. In general, these factors are similar to those affecting penetration of compounds into other types of plant and animal cells.[10, 11, 12] Undoubtedly, other factors will be found as advances are made in the general field of cellular permeability.

Apparently the concept that the epithelium acts as a barrier limiting the penetration of all substance into the cornea is erroneous. This idea has predominated for three quarters of a century because penetration of highly surface-active and nonpolar substances has not been investigated specifically with quantitative methods. These substances penetrate more readily into the epithelium than into the exposed stroma. However, the epithelium does restrict penetration of the

cornea by polar and surface-inactive compounds.

There is considerable variation in the penetration rate of drugs into the cornea. This fact has not received adequate consideration in ocular therapeutics. An example is pontocaine which is a more effective topical corneal anesthetic than procaine; this effectiveness usually has been attributed to greater narcotic potency, but our results indicate that it is due in large part to accelerated penetration. Likewise, the greater efficacy of procaine in alkaline as compared to acid solution may be explained by the more rapid penetration of the free procaine base as compared to the procaine cation.

There are other applications to ocular therapeutics. Highly fat-soluble drugs such as vitamin A, and the free alkaloidal and anesthetic bases should not be administered in oil or fat vehicles, for they are poorly absorbed. Likewise, highly polar, surface-inactive compounds like procaine hydrochloride and doryl are poorly absorbed from simple aqueous solutions.

These studies also have a direct application to the synthesis of new compounds for ocular use. As demonstrated with procaine and pontocaine, two compounds may be similar in basic chemical structure and pharmacologic action, yet differ considerably in penetration rate into the cornea because of dissimilar relations between polar and nonpolar groups within the molecules.

Conclusions

1. Penetration of drugs into the normal cornea is not a simple matter of diffusion. It is a complex process in which multiple interrelated factors determine the rate of penetration. In general, these factors are similar to those affecting the penetration of other plant and animal cells.

2. The molecular structure and resultant physical properties of a drug profoundly affects its penetration rate into the normal cornea. The relationship between polar and nonpolar components of the molecule is of greatest importance, for it determines the surface activity and solubility characteristics of the compound. These physical properties have considerably more to do with the corneal penetration of drugs than does molecular size. The assumption that the penetration rate of compounds into the cornea is in inverse relation to molecular size is not supported by the observations made in these studies.

3. Physical properties of the drug vehicle may profoundly affect penetration rate of a drug into the cornea. The affinity of the drug for the vehicle is particularly important. Polar compounds in water and nonpolar compounds in oil are retained in their respective vehicles and enter the cornea slowly. The partition of polar and nonpolar compounds in the cornea and vehicle simulates to a certain extent the distribution of a solute between two immiscible solvents. The hydrogen-ion concentration, the osmotic pressure, and the presence of surface-tension-reducing agents are other physical properties of drug vehicles directly or indirectly affecting the penetration rate of procaine into the cornea.

4. The generally prevalent concept of the surface epithelium as a simple barrier limiting penetration of all substances into the cornea is erroneous. Some substances penetrate more readily into the cornea when the epithelium is intact.

5. The permeability characteristics of the corneal epithelium and stroma differ considerably. Nonpolar and highly surface-active compounds penetrate more readily and polar compounds less readily into the epithelium than into the exposed stroma. Therefore, injuries to the epithelium increase the penetration rate of polar and surface-inactive compounds but

may decrease penetration of nonpolar and surface-active compounds.

6. Rapid variations in intraocular pressure do not influence penetration into the cornea except by damage to the epithelium.

1. In evaluation of the ocular effects of drugs administered by instillation, penetration rate under varying conditions as well as pharmacologic potency must be considered. The difference in effectiveness of topical anesthetics may be due principally to differences in penetration rate into the cornea.

Bibliography

[1] Duke-Elder, W. S. Textbook of ophthalmology. St. Louis, C. V. Mosby, 1933, v. 1, pp. 472-474.

[2] Nakamura, B. Beiträge zur Kenntnis der Resorption der Hornhaut. Klin. M. f. Augenh., 1923, v. 70, pp. 195-212.

[3] Gallenga, R. Influenza della pressione osmotica sull'assorbimento delle soluzioni medicamentose attraverso la cornea. Arch. di sc. biol., 1926, v. 9, pp. 212-223.

[4] Fischer, F. P. Ueber die Durchlässigkeit der Hornhaut für Alkaloide. Arch. f. Augenh., 1931, v. 104, pp. 121-133.

[5] Antonibon, A. Ricerche quantitative sull'assorbimento della cornea. Ann. di Ott., 1929, v. 57, pp. 58-65 and 134-139.

[6] Colombo, G. L. L'influence de la détente oculaire sur les phénomènes de diffusion dans la cornée pour l'explication de certains faits cliniques. Ann. d'Ocul., 1921, v. 158, pp. 368-375.

[7] Grönvall, H. Citric acid studies referring to the eye. Acta. Ophth., 1937, Supp. 14.

[8] Fischer, F. P. Ueber die Permeabilität der Hornhaut und über Vitalfärbungen des vorderen Bulbusabschnittes mit Bemerkungen über die Vitalfärbung des Plexus chorioideus. Arch. f. Augenh., 1929, vv. 100 and 101, pp. 480-555.

[9] Schroeder, Hans. Action of drugs in glaucoma. The Eye, Ear, Nose and Throat Monthly, 1937, v. 16, pp. 9-12.

[10] Jacobs, M. H. Some aspects of cell permeability to weak electrolytes. Cold Springs Harbor Symposium. Menasha, Banta, 1940, v. 8, p. 30.

[11] ———. Permeability of the cell to diffusing substances. General cytology. University of Chicago Press, 1924, pp. 199-264.

[12] Höber, R. Correlation between the molecular configuration of organic compounds and their active transfer in living cells. Cold Springs Harbor Symposium. Menasha, Banta, 1940, v. 8, p. 40.

[13] O'Brien, C. S., and Swan, K. Carbaminoylcholine chloride in the treatment of glaucoma simplex. Arch. of Ophth., 1942, v. 27, pp. 253-263.

[14] Conant, J. B. The chemistry of organic compounds. New York, The Macmillan Co., 1934, p. 348-381.

[15] Bratton, A. C., and Marshall, E. K., Jr. New coupling component for sulfanilamide determination. Jour. Biol. Chem., 1939, v. 128, pp. 537-550.

[16] Gerlough, T. D. Influence of pH on activity of certain local anesthetics as measured by rabbit's cornea method. Jour. Pharmacol. and Exp. Therap., 1931, v. 41, pp. 307-316.

Discussion

Dr. Jonas Friedenwald (Baltimore, Md.): Mr. Chairman, I believe that Dr. Swan's work has brought the problem of the permeability of the cornea in line with the permeability of many other organs. His statement of the whole problem has greatly clarified the matter.

It seems to me, however, that the emphasis on the polar as against the nonpolar structure, as if these two had opposite and antagonistic actions in respect to penetration, is not quite clear, and I believe that Dr. Swan emphasized the antagonism beyond what he actually intended in his paper.

In order that a substance should go through a lipoidal membrane, which is surrounded on both sides by an aqueous

phase, it has to have affinities both to the water and to the lipoidal membrane, so that the maximum penetration is obtained by substances which have a balanced degree of polar and nonpolar characteristics. Substances that are wholly polar, like inorganic salts or glucose or urea, have, as Dr. Cogan and his co-workers have shown, very little power or penetration through the corneal epithelium. On the other hand, substances that are wholly lacking in polar groups also have very little penetration. Only those substances which combine these two effects are able to get through both phases of this tissue.

That is a characteristic which has been found in a great many other organs, and perhaps the most classical study on these problems has been done by Amberson and Hoeber, who studied the penetration of various substances through the salivary glands, and who found that starting from a substance that is wholly nonpolar, its penetrating power could be increased by adding polar groups; and, starting from a substance that is wholly polar, its penetrating character could be enhanced by adding nonpolar groups. Finally, if substances of a similar balanced structure are compared, then molecular size plays an important role.

I should like to ask Dr. Swan whether that interpretation of his data is correct.

DR. SWAN: That is correct. I am sorry if I gave the impression that polar and nonpolar are two separate entities. They are not. The group of naphthalene derivatives that we studied had both characteristics to varying degrees. I appreciate Dr. Friedenwald's clarifying that point.

DR. SANFORD G. GIFFORD (Chicago, Ill.): I have a question. What conclusions can be drawn as to the penetration of alkaloids not only into the cornea but into the aqueous in various media?

DR. SWAN: That, I think, we will have answered in the second paper. I mentioned the preliminary experiments in which we found that the concentration of compounds in the aqueous was not a direct index of penetration across the cornea. In the living eye, the blood supply through the iris, the activity of the iris, and the passage of the drug into the lens, vitreous, and anterior sclera complicate the matter. For that reason, we separated the two problems; the second phase of this work concerns the factors determining the concentration of drugs in the aqueous as compared to the cornea and other tissue.

DR. CLYDE A. CLAPP (Baltimore, Md.): It has been recently stated that drops instilled on the upper surface of the cornea are absorbed more readily than when placed in the lower cul-de-sac. Does your work substantiate that statement in any way?

DR. SWAN: I think that point was clarified by Laquer about 1876. He demonstrated that absorption into the eye from the conjunctival sac is primarily through the cornea as contrasted to the conjunctiva. Later, Antonibon repeated that work, blocking off the conjunctiva so that only the cornea was exposed and vice versa. As I recall he found with sodium chloride that the ratio of transmission was nine to one in favor of the cornea; that is, 90 percent of the material was transported by the cornea. Instilling a drug over the cornea at the top of the cornea would bring more of the drug into contact with the corneal surface than would instillations into the lower fornix.

EPIDEMIC KERATOCONJUNCTIVITIS*

(SUPERFICIAL PUNCTATE KERATITIS, KERATITIS SUBEPITHELIALIS, KERATITIS MACULOSA, KERATITIS NUMMULARIS)

WITH A REVIEW OF THE LITERATURE AND A REPORT OF 125 CASES

MICHAEL J. HOGAN, M.D., AND JOSEPH W. CRAWFORD, M.D.
San Francisco

This acute inflammatory eye disease appeared in the region of San Francisco in September, 1941, mainly in shipbuilding plants, and was thought by many of the workers to be associated with the welding processes involved in shipbuilding. It spread rapidly among the shipworkers, then became epidemic throughout the city and surrounding territory. The number of cases increased until January, 1942, after which there was a decrease. The disease has been variously named by different authors—superficial punctate keratitis, Fuchs[1, 2]; keratitis subepithelialis, Adler[3]; keratitis maculosa, von Reuss[4]; nummular keratitis, von Stellwag,[5] Dimmer;[6]—but we have chosen the term *epidemic keratoconjunctivitis* as being more descriptive of the acute condition, which is typified by edema of the lids and conjunctiva, followed by intense hyperemia, but with very little discharge. The keratitic spots develop within five to eight days and are 0.5 to 1.5 mm. in diameter. They lie in the superficial substantia propria, beneath Bowman's membrane, and last from two months to two years.

The disease is now being seen in various parts of the United States. Initially we were inclined to consider these cases as being forms of acute catarrhal conjunctivitis or types of Béal's conjunctivitis like those first reported in this country by Thygeson.[7] Only when the corneal changes developed did we realize the true nature of the affection.

In all we have treated more than 200 patients, but this report is based on a review of 125 of these cases in which the patients were seen and examined throughout the course of the disease.

HISTORICAL REVIEW OF THE CLINICAL CHARACTERISTICS

In August, 1889, von Stellwag,[5] under the title "A peculiar form of corneal inflammation," described a type of keratitis that followed a slight conjunctivitis. The corneal foci in his patients were about 1.5 mm. in diameter, mainly peripheral, and lay at varying depths. He was the first to entitle these lesions "nummular," because of their coin shape. Some of them became ulcerated and could be stained. The lesions healed rapidly, so that within 14 days they had disappeared. During the same month, von Reuss[4] published the report of his cases under the title "Keratitis maculosa." They were similar to those of von Stellwag. Apparently the disease was epidemic in Austria at that time. Two months later, Fuchs,[1] under the name "Superficial punctate keratitis," recorded 36 cases of the disease. According to his description the disorder began in the manner of an acute catarrhal conjunctivitis, but with more ciliary injection. From one fourth to one third of his patients developed a bilateral affection. Within from 3 to 14 days the patients suffered pain, photophobia, and blepharospasm, and had a thin, watery secretion. During this time the keratitis

* From the Department of Ophthalmology, Division of Surgery, University of California Medical School. This work was facilitated by a grant from Mrs. E. S. Heller.

made its appearance as the conjunctivitis was subsiding. The early corneal lesions were round, punctate, and either diffusely arranged or grouped along vertical lines. Within a few days they increased in number, and became about 0.5 mm. in diameter. Some of them increased in size by the coalescence of neighboring foci. In the majority of the patients these corneal spots were numerous, but in some there were only 10 or 20 lesions. All of these lesions were located just beneath Bowman's membrane, so that removal of the corneal epithelium did not cause their disappearance. Beneath these infiltrates Fuchs noted fine gray dots and lines like fractures in ice. He also found corneal hypesthesia and anesthesia in a number of patients. The lesions became ulcerated in only four instances. The course of the disease was slow, sensitiveness and irritability persisting for some period of time. In 14 instances Fuchs found that the lesions remained for from six months to one year. He stated that one could be sure that the lesions were gone only after the lapse of one to two years. Permanent opacities were found only in those corneas in which the lesions had ulcerated.

Under the title "Keratitis sub-epithelialis" Adler,[3] during the same month as Fuchs, described the same form of keratoconjunctivitis. Schloesser[8] also published comments on the disease during the same year.

Gunn,[9] from London, in 1890, reported on two patients whose condition was identical with that described by Fuchs. One of Gunn's patients had blurred vision lasting for five months.

The next large epidemic was reported in 1901, by Herbert,[10] from Bombay. He described 226 cases, mostly in young adults, which were seen between January and April, 1901. His patients developed conjunctival and ciliary injection followed by thickening of the limbal conjunctiva. he disease remained unilateral in most instances. The keratitis had its onset soon after the conjunctival symptoms appeared. Minute, faintly opaque, superficial, staining infiltrates were noted. The corneal surface was rough and pitted. The opacities were diffusely scattered, but in the later stages were mainly concentrated centrally. The disease did not seem to be contagious. Herbert believed that a feebly staining, gram-negative bacillus caused the condition. Westhoff[11] and Axenfeld,[12] in 1905 and 1912, confirmed the presence of this bacillus on the cornea. Dimmer[6] described four cases of keratitis nummularis in 1905. The specificity of the disease in his last two cases is somewhat doubtful. Case 3 followed the spraying of acid into the right eye. Redness, photophobia, and blurred vision resulted, and persisted for some time. There was conjunctival and ciliary injection with formation of five gray, round, superficial spots in the outer half of the cornea. One of these spots was ulcerated. The patient was followed for about three weeks only. Case 4 followed the entrance of lime into the eyes. Six weeks later there was dim vision, pain, slight photophobia, and watering. The conjunctiva was markedly hyperemic. The cornea of the right eye showed six gray spots 0.5 to 1 mm. in diameter, and a larger infiltrate 4 by 3 mm. in diameter. These were white, opaque, superficial, and slightly vascularized. One lesion was ulcerated. The patient was lost in three weeks; there had been little change in his condition.

The disease in the first two cases was uncomplicated by an injury. In case 1 there was a bilateral affection with central, superficial corneal macular lesions measuring 0.5 to 1 mm. in size. The second patient had a unilateral affection, with similar lesions just inside the

limbus. There had been no preceding conjunctival inflammation in either case. They were not followed for long.

Dimmer's cases of keratitis nummularis are given in some detail in order to show the similarity of the disease in cases 1 and 2 to the condition noted in subsequent reports of superficial punctate keratitis. That the two conditions should be placed in the same category will become apparent.

In 1909 Wiener[13] reported the first case to occur in this country. His patient was a young woman 21 years of age who developed irritation, lacrimation, and injection of the conjunctiva of the right eye, followed by small, round, superficial corneal opacities which lasted about six weeks. Verhoeff[14] published the pathologic report of a case in 1911. One of the cases published by Gradle,[15] in 1911, under the title "Keratitis subepithelialis," seems to be a member of this group of diseases.

Under the title "Epidemic of macular keratitis," Kirkpatrick[16] described an extensive epidemic that occurred in 1920 in Madras. In his patients the disease began with lacrimation and irritation, but the conjunctivitis was slight. The corneal changes appeared very soon. They involved the superficial substantia propria, Bowman's membrane, and deep epithelium, and were of three types:

1. A superficial punctate keratitis, showing small opaque spots, varying in size from a "pin point" to a large "pinhead." These numbered from 3 to 12 and were irregularly scattered over the cornea. They had soft edges and the surfaces over them were not elevated. There was complete absence of vascular reaction, either circumcorneal or conjunctival.

2. A single large patch, more dense centrally, and linear in shape. Sometimes this patch was raised in the center. One or two soft, detached spots were often seen near the large area. The patch was generally as large as a quadrant of the cornea. This was the type most frequently encountered.

3. A single large patch only; this was dense, dull, sharply circumscribed and often slightly raised, more at the edge than at the center.

As a rule these opacities were very slow in clearing. Some of the punctate variety disappeared in two or three weeks, whereas some patients who had the third type of lesion were under observation for more than a year. Kirkpatrick noted no ulceration of the cornea over these lesions.

Henderson[17] published a case report from England in 1920, and Zentmayer[18] and Watkins[19] published case reports from this country in 1922. Argañaraz and Androgué[20] reported cases of this disease from Argentina in 1927.

In 1930 Wright[21] published two series of cases of "Superficial punctate keratitis" from Madras. He saw about 3,500 cases of this disease between May, 1928, and January, 1930. The disease was bilateral in only 22 instances. It was most frequent in young males, and the greatest incidence was during the fall and winter. The initial symptoms in his early series of patients were slight, except for the hyperemia, limbal edema, and watering. In the later and much larger group, the onset was characterized by severe conjunctivitis and chemosis but very little discharge. The keratitis was likely to occur before the sixth day and the commonest type of opacities were small, gray, nonstaining punctate lesions in the superficial cornea, limbus, or nearby bulbar conjunctiva. The size, number, position, and shape of these spots varied greatly. In general they were round and solid, but numerous instances of angular, ring-form, and disclike lesions were recorded. Most of them varied in size from a pin point to discs 2 mm. in

diameter. The fine lesions lasted only from 12 to 14 days, but the larger opacities sometimes remained as long as two years. Deep keratitis, folds in Descemet's membrane, fine creamy keratitic precipitates, and iritis were frequently encountered.

Wright saw many of Kirkpatrick's patients. He commented that the lesions were similar to the later stages of the corneal disease in his own series.

Zachariah[22] also reported the occurrence of the disease in India at this time. Chambers[23] and Adams[24] reported cases from England in 1931, and Iturburu[25] recorded the occurrence of the disease in Argentina in 1931.

Doggart[26] described 43 cases from London, in 1933. In his patients the disease began with conjunctivitis, followed by small superficial macular lesions. All but four of his patients had bilateral affections. The maculas were slow to absorb, requiring from weeks to months. In the same year Sanyal[27] reported 175 cases from an epidemic in Calcutta, and Kirwan[28, 29] recorded an epidemic in Bengal. The disease in their patients pursued a course similar to that in the patients seen by Wright and Kirkpatrick.

Merrill[30] reported an epidemic of follicular conjunctivitis manifesting swollen, edematous lids and conjunctivas, followed by formation of limbal infiltrates which ulcerated in some instances. It was not definitely proved whether they were related to the disease under consideration. Ling[31] recorded an epidemic in China, in 1936. The disease in his patients corresponded to that described by other authors. In addition, his patients frequently showed the epithelial inclusions of inclusion blennorrhea.

A widespread epidemic occurred in Germany and the Balkan countries from 1932 to 1940 and the disease was particularly evident in Germany between the years 1938 and 1940. Numerous reports were made of this outbreak, notably by Schneider,[32] Löhlein,[33] zur Nedden,[34, 35, 36] Schultze,[37] Behr,[38] Behr and Zeissler,[39] Meesmann and Bachmann,[40] Goedbloed,[41] Jess,[42] Meissner,[43, 44] Smitmans,[45] Schwitalla,[46] Jancke,[47] Nagel,[48] Senger,[49, 50] Ohm,[51] Gildermeister and Peter,[52] Becker,[53] Frank,[54] Marchesani,[55] Roggenkämper,[56] Scheerer,[57] Tertsch,[58] and Bartels and Löns.[59] Prior to this epidemic cases had been reported as "Keratitis nummularis, Dimmer" by Salzmann,[60, 61] Aust,[62, 63] Ješe,[64, 65, 66] Székeley,[67] Sácha,[68] and Pillat.[69] The disease in their patients seemed to begin in a manner similar to that observed in Wright's first group of cases, in that the conjunctival symptoms were minimal. The initial symptoms arose from the keratitis and consisted of irritation, pain, photophobia, and lacrimation. The descriptions and the drawings of the corneal lesions in their patients are identical to those seen in other epidemics of keratoconjunctivitis. A similar epidemic of keratitis nummularis was reported from Java by Mulock Houwer[70] in 1938. Elwyn[71] reported three cases of keratitis nummularis in this country in 1935, and Chen[72] described typical cases from China in 1934.

The first epidemic in the United States was reported by Hobson,[73] in 1938, under the title "Acute epidemic superficial punctate keratitis." He saw 16 cases that developed in a Veterans' Hospital in San Fernando, California. In his cases the disease was identical to that in previously reported epidemics. Hobson found corneal maculas in some patients after a period of one year.

In 1941 Viswalingham[74] published the record of 3,500 cases from Kuala Lumpur, Malaya. The description of the disease in his patients was identical to that seen in our epidemic. In the same year Hamilton[75] reported the occurrence of an epidemic in Tasmania. Holmes[76] recorded the occurrence of an epidemic on the

island of Oahu, Hawaii, in the summer of 1941. In a personal communication he wrote that, in all, there were about 10,000 cases in Hawaii during this outbreak. It is highly probable that the present epidemic on the mainland started from this source.

It was first stated by Wright that the clinical features of this disease are likely to show extensive variation. He thought it was possible that less typical forms have been described among other corneal affections of doubtful nature. That the disease may have a protean form was appreciated also by Fuchs who considered superficial punctate keratitis and keratitis disciformis as resulting from the same agent. Salzmann traced the intermediate lesions between keratitis vesiculosa and disciform keratitis in his patients, which indicated to him that epidemic keratoconjunctivitis may be an intermediate form.

The various descriptions in the literature suggest that there are many possible variations in the disease. The conjunctival symptoms may be mild followed by severe keratitis, or they may be mild followed by a mild keratitis. The corneal signs are also subject to considerable variation, for some lesions can be seen only with the slitlamp, whereas others are disciform in type. Instances are recorded in which both types have been seen in the same eye (Neame).[77]

Behr and Zeissler[39] attached significance to the malaise that occurred with the disease, attributing it to a general toxemia. None of their patients, however, developed fever nor other signs of toxemia. Several patients had "heart weakness" which was thought to result from the effect of absorption of diphtheria toxin from the local affection in the eye. The electrocardiographic studies on these patients were negative and this seems to us evidence against the claim made by these authors. Meesmann and Bachmann[40] stated that malaise and headache may occur in severe cases, but that no fever is found; zur Nedden,[36] on the other hand, noted no general symptoms in his patients.

Clinical course in our patients

The course of the disease in our patients was very similar to that observed and described by Fuchs. Conjunctivitis, acute in onset, was the first symptom. The patients complained of a "sandy" sensation, as if a foreign body were present. In some patients there was intense itching, as in an allergic disease. Within a few hours glassy edema of the caruncle and semilunar fold appeared and spread to the lower cul-de-sac and bulbar conjunctiva (fig. 1). At this stage there was very little hyperemia. Within 24 hours slight edema of the lids and skin with pseudoptosis became evident. Within from 36 to 48 hours the swollen conjunctiva became congested and red and there was some lacrimation. The bulbar conjunctiva was elevated somewhat at the limbus (fig. 2). Most characteristic at this stage was the intense hyperemia and swelling *without discharge*, except for slight sticking of the lids in the morning. Also interesting is the relatively slight discomfort suffered by these patients. The conjunctival edema and redness of the lower lid were more marked than were those of the upper lid. Involvement of the regional lymphatics was found at this time. In about three fourths of the patients the preauricular, angular, submaxillary, and cervical nodes were enlarged, an important early diagnostic sign. The skin of the lids and cheek became tender, presumably from lymphatic involvement. In the mild forms less edema and redness occurred, and there was less lymphatic involvement as well as a comparatively shorter course. In the more severe forms so much edema was present that the conjunctiva was sometimes ballooned out through the palpebral fissure (fig. 3) and

the cornea seemed countersunk. In this form, severe keratitis nearly always followed. The conjunctivitis was follicular in form in 54 patients.

Thirty-one of our 125 patients eventually developed bilateral conjunctivitis. The right eye alone was involved 57 times and the left 37 times. In the few who developed the disease simultaneously in both eyes the infection seemed especially severe and the keratitis was marked. In those in whom the condition became bilateral, the onset in the second eye appeared from three to four days after the first was affected, and in most cases the infection of the second eye was milder. In some instances the conjunctivitis was accompanied by petechial or even larger hemorrhages. Two of our patients had fairly severe ecchymoses of the lids. We made one observation that has not been reported previously in this disease; 17 patients developed extensive, white, fairly thick pseudomembranes covering the palpebral conjunctiva, caruncle, and fold (fig. 4). The membrane was easily removed in some but bled in others. Other patients had transient, milky pseudomembranes on the tarsal conjunctiva of the lids, especially on that of the lower lid (fig. 5). The average duration of the conjunctivitis was 13 days.

Keratitis occurred in about 92 of the 125 patients. It began between the second and eighth days after the onset of the conjunctivitis, usually closer to the eighth day. Bilateral keratitis occurred in 23 patients, the right eye only was involved in 45 and the left in 24. In our opinion it is safe to say that, if the slitlamp is used in examining all cases of bilateral conjunctivitis in which keratitis is present in one eye, some form of keratitis will be seen in the opposite eye. Deep lesions of the substantia propria (maculas) were found in 17 patients and of these 6 had iritis with small creamy, round, sharply defined keratitic precipitates, an aqueous flare, and cells.

In an early case no lesions could be seen when ordinary illumination was used, but after the keratitic spots became macular, they could be seen easily without magnification. The following pictures were seen:

1. Early changes, seen on the first and second days of the infection, were those occurring in any form of conjunctivitis. Many tiny punctate infiltrates of the epithelial-erosion type were seen. They were evanescent and healed as the conjunctivitis regressed. These stained with fluorescein.

2. The typical *macular infiltrates* were observed on about the eighth day. At first a general haze was noticed when examining with the corneal microscope and slitlamp beam. Very soon dotlike opacities appeared in the deep epithelium and substantia propria. These soon coalesced, forming larger foci. The foci, however, could be resolved into dotlike lesions (fig. 6) with hazy margins. As new dots appeared the lesions became sharply bordered. A fine haze was seen in the epithelium between the lesions and over them. The central portion of each corneal opacity was more dense than the peripheral portion, and this central portion was the last to clear. There was no staining with fluorescein. The well-developed lesions were 0.5 to 1.5 mm. in diameter, round or oval, sometimes angular, and varied in number from 10 in mild cases to 100 or more in severe ones (figs. 7 and 8). The central portion of the cornea was most often involved, the intermediate zone showing scattered lesions, and the limbal areas only rare lesions. No conjunctival infiltrates were seen. The corneal lesions were principally located in the superficial substantia propria, beneath Bowman's membrane, although some of them also involved the epithelium. Deeper

Epidemic keratoconjunctivitis (Hogan and Crawford).

Fig. 1. Glassy edema of the caruncle, semilunar fold, lower fornix, and bulbar conjunctiva are characteristic in the early stages.

Fig. 2. The disease is in a more advanced stage. Hyperemia and edema are more marked.

Fig. 3. Typical appearance at the height of the disease. Hyperemia and edema are more marked.

Fig. 4. Pseudomembrane on the conjunctiva of the lower lid, caruncle, and semilunar fold.

Fig. 5. A follicular reaction occurs in half of the patients. Note the pseudomembrane over the semilunar fold and the bulbar conjunctiva.

Fig. 8. Photograph of macular lesions. The conjunctivitis and keratitic symptoms have subsided.

lesions occurred less frequently; 17 of our patients had involvement of the middle layers of the substantia propria, and 6 showed wrinkling of Descemet's membrane together with a cloudy cellular aqueous and fine creamy corneal endothelial precipitates.

Characteristic was the lack of ulceration and vascularization of these lesions. No particular grouping of position of the infiltrates was noted in any of our cases. The corneal infiltrates outlasted the acute conjunctival symptoms by a considerable period. Attacks of irritability often oc-

curred at intervals of two or three days until the lesions disappeared. In most cases the lesions became faint within three months. Several patients, however, showed dense corneal maculas and diminution of visual acuity to 20/40 at the end of four months. Even though the lesions were massed in the center of the cornea, the vision was surprisingly good. The prognosis for ultimate vision is good.

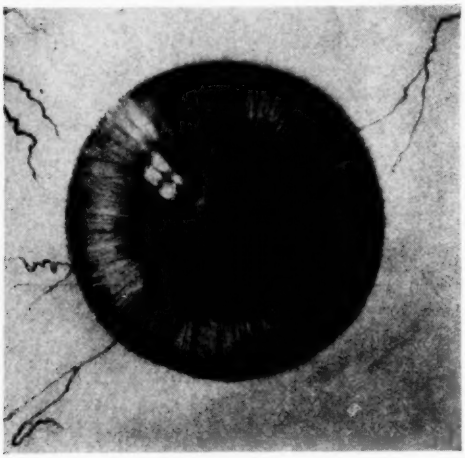


Fig. 7 (Hogan and Crawford). Drawing of the macular lesions. The haze between these maculas results from edema of the epithelium.

3. In several instances there were *gross lesions* consisting of disciform infiltrates about 4 mm. in diameter, in the center of the cornea (fig. 9). These were usually surrounded by small satellite macular lesions. They persisted longer than the maculas and the vision was more affected. In two of the patients they have completely disappeared. There was no ulceration or vascularization of the cornea in this type.

The onset of keratitis in all these forms could be predicted from the symptoms. During the course of the conjunctivitis the patients remained comfortable. Suddenly severe pain, photophobia, lacrimation, and blepharospasm occurred. These symptoms persisted until the keratitis subsided, usually about a week. In some patients, however, the pain lasted two or three weeks. Contrary to some descriptions we did not observe that the lesions disappeared and new ones appeared from time to time. Once these lesions developed they remained, fading gradually from the periphery toward the center, finally leaving only a shining, silicalike circular lesion.

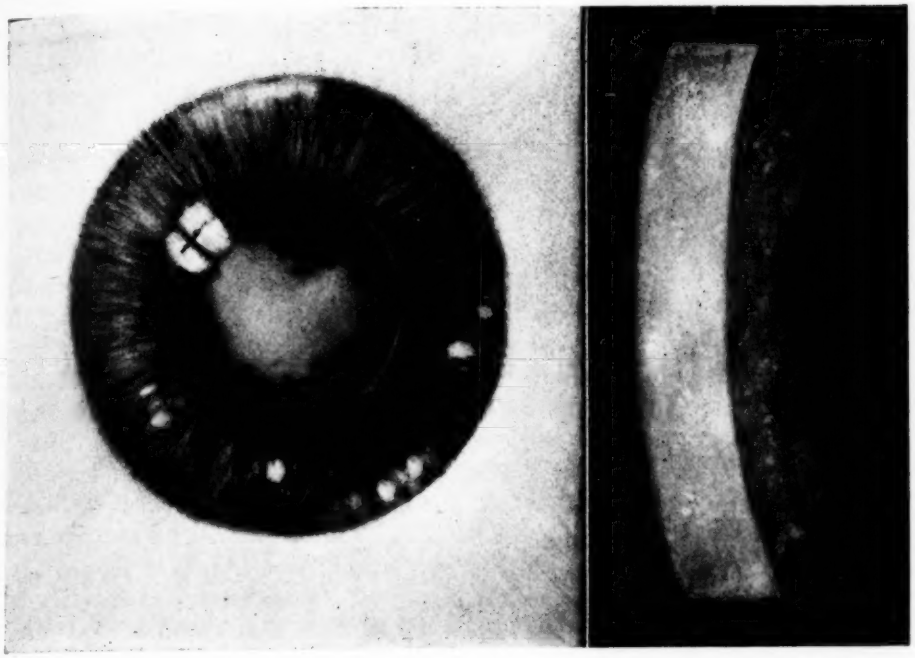
Though hypesthesia or anesthesia has been reported by many authors, the corneal sensibility probably is normal in most patients. Only two or three patients with hypesthesia were encountered in our group. The test for corneal sensibility is difficult to perform and the results depend on many factors. If the reader will try the test on himself as well as on others, he will realize the difficulties of interpretation.

Even in the most severe cases 20/30 vision was usually attained at the end of three months; ordinarily such vision was present within six weeks. Patients were likely to complain of halos around lights, especially at night, until the opacities were gone.

Though slight malaise was present in a few of our patients, probably as a result of the discomfort caused by the keratitis, none developed fever or other signs of toxemia.

Epidemiology

It is probable that the disease is endemic in the Far East where the largest epidemics have been reported. Sporadic cases occur throughout the world, possibly through transfer by persons from these endemic areas. It is fairly certain that the epidemic on the Pacific Coast was brought from Hawaii. Numerous authors have noted that occupation, nutrition, race, and social status play no part in the development of the disease.[21, 38, 74] These authors are somewhat divided in their opinion as to the communicability of the disease, but in general believe that it is not highly contagious.



Macular infiltrates (Hogan and Crawford).

Fig. 9 (left). Drawing of the disciform infiltrate occurring in one patient. Note the macular infiltrates which surround it.

Fig. 6 (right). In this drawing the maculas are seen to occupy the superficial substantia propria. They are composed of many fine dots, more densely aggregated in the center of the lesions.

A large proportion of our patients (101) came from one shipyard in San Francisco. The others were townspeople and a few hospital employees. The latter had had no contact with the eye clinic. No local industrial irritant or chemical could be found as a cause of the disease. In some instances there were reports of one man's using the goggles or the tools of a person infected with the disease, but these were uncommon. The disease seemed to be spread by close contact, with direct transfer of the infectious agent. Individual susceptibility played a great part in the transfer of the disease. There were only five instances of transmission to the wives of infected patients. The organism probably survives only a short period when out of contact with the human body, otherwise more persons would be infected during an epidemic. The dosage of the organisms received also determines the severity of the infection in each case. We believe that the disease is contagious but not to an exceptional degree. Close contact, unhygienic surroundings, and a susceptible population probably played a part in our epidemic. Preventive measures have so far been ineffective. It is suggested that patients contracting the disease be isolated from their fellow workers for a period of at least 15 days, or until the conjunctivitis is nearly well.

Discussion of clinical characteristics

Fuchs originally entitled the disease "Superficial punctate keratitis," and it has been described under this heading many times. This term, however, seems to us inadequate when the disease is in the epidemic form, for the following reasons: 1. It is primarily a conjunctival disease in

most cases, the corneal involvement being secondary. 2. Many patients with the typical conjunctival picture fail to develop keratitis. 3. In but few is the corneal change punctate in nature; the lesions are more likely to be from 0.5 to 1.5 mm. or more in diameter.

Consequently the term *epidemic keratoconjunctivitis,* which seems to us much more nearly descriptive of the disease under discussion, has been used. From the literature it is evident that considerable confusion exists in the proper differentiation of this form from superficial epithelial erosions. In our opinion epidemic keratoconjunctivitis should be kept as a separate entity.

It is generally agreed that the incubation period of the disease varies from 5 to 12 days, and commonly is about 8 days.[21, 40, 76] Young adults seem to be most affected (our own patients ranged in age from 18 to 40 years) but nearly all authors comment that the disease is rare under the age of 12 years. In most epidemics, males seem to be affected in a ratio of two or three to one over females. The disease is more prevalent in the fall, reaches a peak during the early winter months, and tapers off in incidence toward spring.[10, 21, 23, 25, 78] All races are affected.[10, 16, 21, 31, 74] The occupation of the patient seems to have no influence, for epidemics have been recorded in agricultural workers[11, 21, 72, 76] as well as in industrial workers.[34, 35, 36, 38] Close contact in work seems to favor transmission of the disease.

Descriptions of the conjunctival signs are remarkably alike[12, 38, 43, 44, 74] in most epidemics. That far more cases are unilateral than bilateral is corroborated by numerous authors.[1, 43, 44, 62, 63, 64, 65, 72] Wright, for example, found only 22 instances of bilateral involvement in 3,500 cases. On the other hand, zur Nedden and Meissner found a higher incidence of bilateral involvement. In the few patients who develop the disease simultaneously in both eyes the infection seems especially severe and the keratitis marked.

The occurrence of keratitis varies in different epidemics; for instance Meesmann and Bachmann gave the figure as 15 percent, Behr, 5 percent, and Meissner, 50 percent. The incidence is high in those epidemics occurring in the Far East. The onset of the keratitis occurs on about the eighth day of the disease, but there is considerable variation in this also. Meissner gave the time as from 7 to 21 days, Schwitalla from 2 to 6 days, Smitmans from 8 to 12 days, and Fuchs from 2 to 14 days. Reports of the occurrence of bilateral keratitis vary; for example, zur Nedden's cases were unilateral, while two thirds of Ling's were bilateral. Gross corneal lesions of a bizarre form are more frequently reported from the epidemics in the Far East. Mulock Houwer's article contains beautiful illustrations of the ring-form and disciform lesions that appear in these patients.

The paucity of reports on keratitis nummularis (Dimmer) prior to 1933 and the great number of cases reported thereafter[62-69] indicates that an unusual number of patients with this disease were being seen. These authors commented that the early stages of the disease were not being seen. Their patients only rarely gave a history of conjunctivitis. Such a history is not necessary, however, in view of the fact that most of the patients whom Wright saw early in the course of the disease had little or no conjunctivitis. Other authors[36, 43, 44] in Germany reported instances of the keratitis with only a very mild degree of conjunctivitis or none at all. On the other hand, during a severe epidemic, marked conjunctivitis, even with the formation of pseudomembranes, may be seen, though keratitis is not present at that time nor does it ap-

pear. These findings should indicate that the disease has many forms, some of them atypical. In our opinion, epidemic keratoconjunctivitis, keratitis nummularis (Dimmer), Béal's papillary form of conjunctivitis, and some forms of keratitis disciformis should be included in one disease entity. It is difficult to explain the wide variation in the occurrence of keratitis. Apparently in some epidemics the corneal symptoms predominate, while in others the conjunctival symptoms are more evident. Another point for emphasis is that these lesions may not lie immediately beneath Bowman's membrane.[16, 21] Deep forms occur, with wrinkling of Descemet's membrane and iritis.

Etiology

The cause of the disease is not yet determined. Most authors now agree that it is not typically bacterial in origin. Many other factors have been mentioned, for example, herpetic virus, other viruses, bacterial infections of various kinds; neuropathic, allergic, parasitic, and nutritional causes; injuries and upper respiratory infections also have been considered to play a part. In general, the findings recorded in the literature can be placed under the headings listed below.

1. viruses: *A. Herpes virus* has been considered as the etiologic agent, either the virus as usually found or an attenuated or altered form. Other workers have believed the virus concerned to be related to the herpes group. Fuchs first noted the resemblance between some of the herpetic lesions and the one he called "superficial punctate keratitis." He also noted them as being unlike in an absence of vesicles, the number of spots, and the more frequent bilaterality of epidemic keratoconjunctivitis. Grüter[79, 80] stated that herpes virus has two forms, the more virulent of which causes dendritic keratitis, the milder form causing superficial punctate keratitis, vesicular keratitis, recurrent erosions, and keratitis disciformis. In his opinion, incongruous lesions are caused by a modified virus. Salzmann thought the herpes virus capable of causing varied lesions. He traced intermediate lesions between vesicular keratitis and keratitis disciformis. Ješe[65, 66] concurred in this belief. Neame[77] felt that "superficial punctate keratitis" is caused by a variety of viruses, such as herpes facialis, herpes zoster, measles. Other authors[36, 43, 44, 46, 47] regarded the herpes virus in modified form as a possible causative agent of the disease. There are many recorded instances of the occurrence of herpes facialis, dendritic keratitis, and vesicular keratitis with or preceding epidemic keratoconjunctivitis.[31, 67, 81] Fage and Löhlein, on the other hand denied any relationship of the herpes virus to epidemic keratoconjunctivitis. Their contention is supported by the frequently negative experiments on animals. Ordinarily the herpes virus will cause keratitis and subsequent encephalitis with death in rabbits inoculated with material from herpetic patients. In no instance of epidemic keratoconjunctivitis has this occurred. Jancke reported the development of keratitis in rabbits and guinea pigs, but encephalitis was not induced. Others conducting such experiments, including ourselves, were unable to confirm Jancke's results. Against herpes as the causative factor in epidemic keratoconjunctivitis, then, may be marshalled the following facts: (1) Vesicles are very rarely present in this keratitis, nor does ulceration occur; (2) there is no constant corneal anesthesia; (3) inoculation of rabbits with material from patients having the disease has failed to produce lesions characteristic of herpes; and (4) the ophthalmic lesion in this condition is frequently bilateral, in contrast to herpes.

B. Other viruses. Wright was the first

to pursue the course further. He was able to transmit the corneal disease to one rabbit and three human beings by employing unfiltered conjunctival washings from patients. Monkeys were unaffected. In addition, he was able to transmit the disease to five human beings after the filtration of washings through Kitasato candles. He noted, however, that the pressure of filtration and sterility of the filtrate were not checked in all instances. He also found obvious corneal epithelial inclusions, both nuclear and cytoplasmic, the size and staining of which varied. They were found in large numbers near the corneal lesions. In addition, five of seven preparations of corneal epithelium stained with hematoxylin and eosin showed patches of minute, ovoid, elongated particles lying on the epithelial cells. These were not seen in the scrapings, and could not be cultivated; they were thought to be rod-organisms.

Of 42 attempts at corneal inoculation in rabbits, Jancke got 14 positive results. The lesions consisted of infiltration of the scratch marks, slight conjunctivitis, and swelling of the lids. One animal developed a dendritic keratitis. In another experiment, Jancke inserted small bits of human conjunctiva into the conjunctivas of rabbits, in 31 instances. Five rabbits developed lesions varying from follicular conjunctivitis to keratitis disciformis and several had a punctate keratitis. In addition, material was scratched onto the corneas of 15 rabbits; in 10 of these keratitis was produced, radiating out from the scratch marks in tonguelike fashion. In others isolated punctate lesions were seen. Subcutaneous, intraocular, and intracerebral inoculations were all negative.

Hamilton found tiny petechial lesions on the skin in many cases. He interpreted these as resulting from nerve lesions caused by a virus. Viswalingham was able to transmit the conjunctival disease to four of six human volunteers by instilling conjunctival washings from the patients. The disease developed within 12 to 36 hours and was well in from six to eight days. The cornea became involved in one patient. Transfers from two of these patients to others resulted in a mild temporary conjunctivitis. Because bacteriologic studies were negative, Viswalingham was convinced that the disease was caused by a virus of considerable toxicity. Dresel[82] had four successful "takes" from eight patients on the chorioallantois of chick embryos. The embryos, which were from 9 to 10 days old, died in from 72 to 96 hours after edema and opacities occurred on the membrane. In one case the questionable virus was able to pass through four embryos without losing its specific reaction. Dresel concluded that the disease was probably caused by a virus that might be related to herpes. Schneider[32] was unable to confirm this.

2. BACTERIA. Numerous instances are recorded of the occurrence of pathogenic bacteria in epidemic keratoconjunctivitis, but the findings have not been constant. Nuel[83] found micrococci in the epithelium, Watkins,[19] staphylococci; Aust considered the disease to be possibly of fungus origin.

In about 30 of 36 instances Herbert found an encapsulated gram-negative bacillus that stained faintly. It grew on the epithelium, especially near the lesions. He was unable to cultivate it. Axenfeld[12] examined some of the scrapings obtained by Herbert from these cases and confirmed the presence of the organisms. Westhoff[11] found a similar bacillus in some cases. Others, however,[16, 21] were unable to confirm these findings.

Behr, and Behr and Zeissler found diphtheria bacilli of diminished virulence in 12 of 30 cultures. Accepted tests for the pathogenicity of these organisms were

positive, though the guinea pigs were not killed. Gildermeister and Peter,[52] however, reinvestigated Zeissler's 12 strains but found no diphtheria bacilli among them. zur Nedden[35] questioned the pathogenicity of Zeissler's organisms, pointing out that an organism of such low virulence would hardly cause such a severe conjunctivitis and keratitis. Others, too, were unable to find diphtheria bacilli in the cultures.[40, 42, 48, 82]

3. NEUROPATHIC ORIGIN. Verhoeff[14] considered the lesions to be neuropathic in origin, offering the explanation that irritation of the corneal nerves caused liberation of toxins around the nerve channels in Bowman's membrane. The toxins aroused body defenses with accumulation of polymorphonuclear leucocytes around the nerves, resulting in the opacities seen clinically. He ascribed a neuropathic lesion as the primary factor for the following reasons: (1) The resemblance of the lesions to herpes and dendritic keratitis as well as their apparent relationship to upper respiratory infections. (2) The lowered intraocular tension. (3) The presence of corneal hypesthesia. (4) The absence of limbal involvement. (5) The evidence of deep staining with fluorescein in the presence of intact epithelium, which he considered characteristic of deep-seated neuropathic lesions. Verhoeff also pointed out the occurrence of punctate infiltrates around the disciform keratitis. Herpes facialis, superficial punctate keratitis, disciform keratitis, chronic relapsing keratitis, the so-called metastatic gonorrheal conjunctivitis and keratitis, and Fuchs's epithelial dystrophy were all placed by Verhoeff in the same neuropathic group.

4. OTHER CAUSES. Kirkpatrick thought that most cases were parasitic and nutritional in origin, but he was unable to find the parasite. Hobson[73] attributed the disease to an allergy. Mulock Houwer and Westhoff believed "sawah mud" or "rice-field mud" to be a factor in the infection of Javanese natives. Ling found inclusion bodies in the epithelial cells in 50 percent of his cases. He did not attempt to relate inclusion blennorrhea and epidemic keratoconjunctivitis, merely stating that during the summer months when many persons were swimming in large pools he encountered the two conditions. In his early series zur Nedden[34] found epithelial inclusions in three patients, but none was encountered in subsequent examinations. Many authors[34, 35, 40, 42, 57] considered a primary injury of slight nature, or a surgical procedure, sufficient to cause the disease if the patient were exposed to the virus.

For the following reasons it seems probable that the disease is caused by a virus: (1) The results of bacteriologic investigation have been almost universally negative. The few positive observations reported were usually questioned, on further check, by two or more investigators. (2) The "takes" that occurred in Wright's patients who were inoculated with filtered material are indicative of the presence of a virus. These experiments are somewhat open to question because Wright did not test the sterility of the filtrate in every case but, in those instances in which the filtrate was known to be sterile, "takes" were obtained. (3) The disease can be transmitted from human being to human being even in the absence of positive bacteriologic findings. (4) The early and rapidly progressive involvement of the lymphatics of the lids and conjunctiva and of the regional lymph apparatus is more typical of the reaction to a virus than of any other cause. (5) Failure of the corneal infiltrates to break down and ulcerate, as well as their complete disappearance in most cases, tends to prove that a virus rather than bacteria is the activating organism.

On some occasions respiratory infections preceded the onset of the disease.[1, 23, 24, 84]

We attempted to determine the cause of the disease in our patients. Some of the work is not yet completed and will be reported later.

The following routine was established: On admission, each patient had a complete ophthalmic examination. In severe cases the patients were observed daily; in the less severe, at intervals of two or three days. At each visit the patient was examined with the slitlamp and corneal microscope. Conjunctival material was taken on swabs and planted on blood-agar plates, mannitol-agar plates, and in beef broth. Smears and scrapings were taken from the anesthetized conjunctiva. These were stained according to the methods of Gram and of Giemsa. In five patients scrapings of corneal epithelium were taken with a spatula and smeared on glass slides. These were also stained with Giemsa stain. Biopsy specimens of the conjunctival epithelium and conjunctival tissues were taken from various regions of the conjunctiva in 10 patients. These specimens were embedded in paraffin and stained both with hematoxylin and eosin and according to Gram's method. Washings and scraped epithelium from many other patients were pooled in normal salt solution and used for inoculation of animals.

The cultures were incubated at 37°, for 72 hours, or longer if deemed necessary. Some were incubated anaerobically and some aerobically. The most common organisms encountered were hemolytic and nonhemolytic Staphylococcus albus and Corynebacteria. The growth on most plates was scanty. Only rarely were pathogenic bacteria encountered. Most of the staphylococci found did not ferment mannitol, indicating that they were probably nonpathogenic. In 10 instances, colonies of Corynebacteria were removed from the plates, inoculated into broth, and incubated for 48 hours. In each instance 1 c.c. of the broth was injected intradermally and intraperitoneally into two guinea pigs, as is done in the usual test for the pathogenicity of organisms of the Corynebacterium diphtheriae group. None of the animals lost weight or became ill over a period of two months. There was no necrosis at the site of the intradermal inoculations. Consequently it seems unlikely that these organisms were pathogenic Corynebacteria.

Scrapings of conjunctival epithelium, and smears from the conjunctival sac, which were stained with Gram's and Giemsa's stains, showed no virus particles in the epithelium. Occasional staphylococci were found. The most outstanding observation was that the exudate was predominantly lymphocytic, a fact not previously recorded by investigators. In only one instance out of the 125 cases was there a polymorphonuclear leucocytic exudate, and it is our opinion that the patient in this case had a bacterial infection coincident with the disease, although the bacterium could not be determined. The finding of a lymphocytic exudate was so constant in the preparations that we came to consider it a valuable aid in the diagnosis of early cases.

The five instances in which we examined corneal scrapings showed that there were no particular changes in the epithelium. Bacteria such as those described by Herbert, Axenfeld, and Westhoff were not seen.

The 10 conjunctival biopsy specimens were sectioned serially; the principal changes are reported under pathologic findings. We could find no bacteria nor virus particles in the epithelium.

Sixty-three of the workers complained of having suffered a flash, or corneal foreign body, about 5 or 10 days before onset

of the keratoconjunctivitis. It is difficult to conceive how a small corneal injury could cause such a severe conjunctivitis followed by keratitis. Why did not the infection develop in the cornea around the injury? Moreover, the trauma described in a vague statement of "flash" or "some dust in the eye" seems hardly severe enough to be a factor in this disease. Rather is it probable that there is a definite susceptibility to this particular disease in various persons, similar to the susceptibility to herpes shown by some. Close contact and crowded conditions aid in the spread of the disease among any group of workers.

In our cases the occupation itself seemed to have no bearing on onset of the disease, as there were many instances in which housewives, druggists, dentists, bankers, and business men as well as the industrial group were affected.

All of our patients were in an excellent state of nutrition, so this factor may be disregarded so far as our series is concerned.

Pathology

Pathologic reports in this condition are few. Fuchs[1] speculated that: (1) The corneal punctate spots might result from enlarged corneal corpuscles and granular débris in the lymph channels. (2) The grouping of the lesions suggested involvement of the corneal-nerve channels. (3) The infiltrates could not be cellular because of the rapid onset, mildness, and lack of ulceration. (4) The fluid exudate which accumulated in the basal epithelium caused its elevation. He did not explain, however, why the lesions remain unchanged for so long if they are only corpuscular and caused by débris.

Von Stellwag found not only cells, but cocci in the infiltrates. Nuel[78, 83] examined pieces of cornea shaved from the periphery, in which he found lymphatic stasis. The anterior intralamellar spaces were dilated and the epithelial cells edematous. The spots were formed by filamentous networks that became hyalinized, and these were connected with the corneal corpuscles. No inflammatory cells were seen. The epithelium was edematous over the spots. One specimen showed some micrococci in the spaces. Wehrli[85] found lesions made up of dense lymphocytic accumulations involving only the epithelium. These lesions were very minute.

Verhoeff[14] examined an eye that was removed because of a severe iritis and pain lasting two weeks. He did not see the eye before removal. Grossly there were 15 gray spots, varying in size from 0.03 to 1.0 mm., most of which were central. Microscopically, the spots were composed of collections of polymorphonuclear leucocytes that had undergone necrosis and lay under Bowman's membrane. The anterior corneal lamellas were also infiltrated diffusely with inflammatory cells. Some leucocytes passed from the necrotic foci through nerve canals in Bowman's membrane to lie below the epithelium where they had become necrotic. In this eye also the iris showed small angiomas. Verhoeff explained the lack of subsequent scarring in these cases as due to the fact that the lamellas were split apart and not destroyed.

Wright fixed sheets of corneal epithelium in Zenker's solution and stained them with hematoxylin and eosin. The diseased epithelium took the stain poorly and was somewhat thinned out. The bodies of the epithelial cells were broken up and the nuclei fragmented. No leucocytes were seen, but Wright pointed out that they could have been washed out in preparation. He thought that the degeneration of the epithelial cells caused the epithelial opacities. As mentioned previously, biopsy specimens were taken from various portions of the conjunctiva in 10 of our pa-

tients. These specimens were embedded in paraffin, sectioned serially, and stained either with hematoxylin and eosin or Giemsa's stain. The conjunctival epithelium was found to be infiltrated with lymphocytes. These cells also were scattered diffusely and perivascularly in the subepithelial connective tissue. There were no virus particles in the epithelial cells, and no bacteria were encountered. We searched for evidence of nodular conjunctival lesions, such as those seen in the cornea, but found none. In the corneal epithelium there were no areas that stained faintly, as described by Wright. We also removed epithelium from the cornea over definite macular infiltrates, smeared it on slides, and stained it with Giemsa's stain; there was neither abnormal staining nor were there foreign particles.

While we have no pathologic evidence to support our contention, we think that the lesions are probably in the nature of an acute dilatation and swelling of the corneal lymphatics with edema of the affected tissues, whether they be epithelial or in the substantia propria of the cornea. The lymph spaces eventually become filled with débris. In the more severe cases, in which actual destruction of tissue occurs, a resulting corneal macula forms. This macula lasts a considerable time, then gradually clears, as is seen in many corneal opacities. It remains to be seen whether the lesions are caused by an infiltration of the cornea with acute and chronic inflammatory cells, and show destruction of the corneal lamellas.

Differential diagnosis

Acute catarrhal conjunctivitis, Béal's conjunctivitis, and lacrimal conjunctivitis must be considered in the differential diagnosis. The keratitis is fairly specific and is unlikely to be confused with any other lesion.

The cases of superficial punctate parenchymatous keratitis recently reported by Davis[86] do not fit into the clinical picture under discussion. As contrasted with those of epidemic keratoconjunctivitis the corneal lesions in his patients were very faint, lasted only a short time, and were subject to recurrence.

The resemblance of the conjunctival form of keratoconjunctivitis to Béal's conjunctivitis has been mentioned. Béal's conjunctivitis has no known corneal complications. It may be that the two are forms of the same disease, or are caused by closely related viruses.

In the first 24 hours the glassy edema and intense itching may suggest that the disease is allergic. There are no eosinophiles in the smears and scrapings, however, and the subsequent course serves to rule out this state.

Meissner[43, 44] and Schwitalla[46] stated that they were unable to make the diagnosis in the absence of typical keratitis. Behr[38] disagreed, feeling that it is possible to be fairly certain in most of the early cases.

The diagnosis may be made early if the following points are kept in mind:

1. The sudden onset, with glassy edema of the caruncle, semilunar fold, lower cul-de-sac, and bulbar conjunctiva.

2. Early occurrence of tiny petechial hemorrhages on the mucous membrane in some instances.

3. The severity of the conjunctival signs in the *absence of any discharge.*

4. Enlargement of the preauricular and other regional nodes, which usually occurs early.

5. The absence of causative bacteria in smears and cultures.

6. The presence of a lymphocytic type of exudate in smears and scrapings instead of a polymorphonuclear exudate that is seen in other acute forms of conjunctivitis.

Treatment

Many authors have given credit to the use of mild antiseptics and covering of the diseased eye.[16, 21, 23, 76, 78] It is generally agreed that the use of strong antiseptics is contraindicated. Many German authors have credited silver-protein solutions and silver nitrate with good results whereas others felt that these solutions were of no value.

Behr claimed striking results from the use of eye drops consisting of a 1 to 1,000 dilution of diphtheria antitoxin in normal saline solution. These drops were administered hourly until the conjunctivitis was entirely well. Behr claimed that cures occurred in from three to four weeks. This period is comparable to that of "cures" obtained with many different forms of treatment. Meesmann and Bachmann concurred in Behr's results, but zur Nedden felt that the effect of the antitoxin was nonspecific. Roggenkämper[56] claimed good results from the use of drops of a 1 to 1,000 solution of adrenalin, and iodine drops in various forms have been recommended.[36, 76, 87] Scheerer relieved patients by administering roentgen therapy, 100 r, to the eyes.

In our cases therapy proved of little benefit in most instances. The onset of keratitis was not prevented in the severe cases. Likewise, once the conjunctivitis became severe, no treatment changed its duration. In the milder forms of the disease, symptomatic therapy as outlined below seemed to give some relief.

1. Iced compresses gave more comfort than heat. Cold probably reduced the swelling, while the edema of the globe was aggravated by heat. The compresses were applied for 15 minutes every two hours.

2. With the advent of the keratitis, the pain and photophobia seemed to be alleviated considerably by the use of 1-percent atropine sulfate drops three times a day.

3. Constant covering of the affected eye from the beginning of the disease seemed to benefit most patients. No harm resulted from this practice, as there was no discharge from the conjunctiva.

4. Quinine bisulfate ointment, 2 percent, massaged into the eye twice a day seemed to assist in the removal of the infiltrates after the inflammation subsided.

In our experience, the use of silver nitrate locally was of little or no value.

Aside from the palliative therapy noted above, treatment of our patients was instituted along one of three lines:

1. Roentgen therapy, a total of 150 r, was given in divided doses of 50 r each on three successive days. This therapy was administered with the tube at a distance of 30 cm. at 100 kilovolts and 10 milliamperes. A filter of 1 mm. of aluminum was used.

2. Sulfonamide ointment (5 percent) was used locally six times daily. Usually

TABLE 1

Results of treatment of 125 cases of epidemic keratoconjunctivitis

Treatment	Number of Patients	Average No. Days from Onset to 1st Treatment	Number Days from 1st Treatment to Relief of Acute Symptoms		
			Maximum	Minimum	Average
Roentgen therapy	22	8	33	5	13
Sulfonamide ointment	71	4	17	5	13
Combined	32	3	24	2	8

sulfathiazole or sulfadiazene was employed.

3. A combination of roentgen therapy and the use of sulfonamide ointment was employed.

The results of these three forms of therapy are tabulated by the type of treatment and the interval between the onset of the disease and treatment (table 1). No conclusion can be drawn, but there is a suggestion that the combination of sulfonamide ointment with roentgen therapy may be more beneficial than either used alone.

Summary and Conclusions

This paper reports the occurrence of a severe epidemic of keratoconjunctivitis occurring in, but not limited to, shipyard workers. In all 125 cases are reported.

The disease we have described is a superficial keratoconjunctivitis which, because of its epidemic form, should be called epidemic keratoconjunctivitis. This disease has been described under various names such as keratitis nummularis (Dimmer) and some forms of keratitis disciformis associated with superficial macular lesions. From its appearance and history the disease suggests a relationship to Béal's form of conjunctivitis. Superficial epithelial erosions should not be classed with the disease under discussion.

There is great variation in the clinical picture, even during epidemics. Seventy-five percent of the conjunctival infections are unilateral. Diagnostic in the early stages are the glassy edema of the conjunctiva, involvement of the regional lymph apparatus, the lymphocytic type of conjunctival exudate, tiny petechial hemorrhages, pseudomembrane formation, and the lack of discharge. The severe conjunctivitis may or may not be followed by keratitis. Keratitis occurs in about 75 percent of the cases, though this figure varies in different epidemics. At times keratitis occurs without a history of preceding conjunctivitis.

The disease is most likely caused by a virus, the nature of which is unknown but which may be related to the herpes-facialis group. The disease is not highly infectious. It is transmitted by direct contact to susceptible persons, and individual susceptibility varies.

Therapy is of little avail except possibly in the early stages and in milder cases. The disease is self-limited.

The ultimate prognosis is good as regards vision.

Bibliography

[1] Fuchs, E. Keratitis punctata superficialis. Wien. klin. Woch., 1889, v. 2, Oct., pp. 837-841.
[2] ———. Ringform and disciform keratitis. Klin. M. f. Augenh., 1901, v. 2, pp. 513-523.
[3] Adler, H. Keratitis sub-epithelialis. Centralbl. f. präkt. Augenh., 1889, v. 13, pp. 289-295, 321-327.
[4] v. Reuss, A. Keratitis maculosa. Wien. klin. Woch., 1889, v. 2, pp. 665-666.
[5] v. Stellwag, K. A peculiar form of corneal inflammation. Wien. klin. Woch., 1889, v. 2, Aug., pp. 613-614.
[6] Dimmer, F. Nummular keratitis and its related corneal inflammation. Zeit. f. Augenh., 1905, v. 13, pp. 621-635.
[7] Thygeson, P. Acute follicular conjunctivitis, Béal's type. Arch. of Ophth., 1935, v. 13, pp. 853-854.
[8] Schloesser, C. Comments on keratitis punctata. Centralbl. f. prakt. Augenh., 1889, v. 13, p. 360.
[9] Gunn, M. Two cases of superficial punctate keratitis. Trans. Ophth. Soc. United Kingdom, 1890, v. 10, pp. 79-80.
[10] Herbert, H. Superficial punctate keratitis associated with an encapsulated bacillus. Ophth. Rev., 1901, v. 20, pp. 339-345.
[11] Westhoff, C. H. A. Keratitis punctata tropica. Centralbl. f. prakt. Augenh., 1912, v. 36, pp. 289-293.
[12] Axenfeld, T. Demonstration of Major Herbert (Bombay) in keratitis punctata superficialis

of an intraepithelial bacillus. Ber. ü. d. Versamml. d. Deutsch. Ophth. Gesellsch., 1905, v. 32, pp. 307-309.
[13] Wiener, Meyer. Keratitis punctata superficialis, with report of a case. Arch. of Ophth., 1909, v. 38, pp. 120-124.
[14] Verhoeff, F. H. The pathology of superficial punctate keratitis, with remarks on neuropathic keratitis in general, and on a hitherto undescribed lesion of the iris. Trans. Amer. Ophth. Soc., 1911, v. 12, pp. 791-816.
[15] Gradle, H. S. Keratitis punctata subepithelialis. Arch. of Ophth., 1911, v. 40, pp. 534-539.
[16] Kirkpatrick, H. An epidemic of macular keratitis. Brit. Jour. Ophth., 1920, v. 4, pp. 16-20.
[17] Henderson, T. Superficial central keratitis. Trans. Ophth. Soc. United Kingdom, 1920, v. 40, p. 378.
[18] Zentmayer, W. Superficial punctate keratitis. Trans. Coll. Phys. Philadelphia, 1922, v. 44, 292.
[19] Watkins, E. D. Superficial punctate keratitis. Amer. Jour. Ophth., 1922, v. 5, pp. 546-548.
[20] Argañaraz, R., and Androgué, E. Keratitis punctata superficialis (Fuchs). Rev. Espec., Buenos Aires, 1927, v. 2, pp. 333-343.
[21] Wright, R. E. Superficial punctate keratitis. Brit. Jour. Ophth., 1930, v. 14, pp. 257-291; 595.
[22] Zachariah, G. Superficial punctate keratitis. Proc. All-India Ophth. Soc., 1930, v. 1, pp. 50-59.
[23] Chambers, E. R. Keratitis punctata superficialis. Brit. Med. Jour., 1931, v. 1, pp. 750-751.
[24] Adams, P. H. Doyne Memorial Lecture. Trans. Ophth. Soc. United Kingdom, 1931, v. 51, pp. 440-442.
[25] Iturburu, J. C. Keratitis punctata superficialis of epidemic character. Rev. Oto-Neuro-Oft., Buenos Aires, 1931, v. 6, pp. 500-504.
[26] Doggart, J. H. Superficial punctate keratitis. Brit. Jour. Ophth., 1934, v. 18, pp. 65-82.
[27] Sanyal, Saradindu. Epidemic superficial keratitis. Amer. Jour. Ophth., 1933, v. 16, pp. 390-393.
[28] Kirwan, E. O'G. Epidemic superficial punctate keratitis in Bengal. Proc. All-India Ophth. Soc., 1933, v. 3, p. 1.
[29] ———. Epidemic superficial punctate keratitis in Bengal. Fol. Ophth. Orient., 1934, v. 1, pp. 345-356.
[30] Merrill, H. G. Epidemic keratoconjunctivitis diversiformis. Amer. Jour. Ophth., 1936, v. 19, pp. 1007-1008.
[31] Ling, W. P. Keratitis punctata superficialis and swimming pool conjunctivitis. Chinese Med. Jour., 1936, v. 50, pp. 1381-1392.
[32] Schneider, R. Epidemic of keratoconjunctivitis in Munich and surroundings. München. med. Woch., 1938, v. 85, pp. 1981-83.
[33] Löhlein, W. Discussion, Becker,[53] Klin. M. f. Augenh., 1939, v. 102, p. 868.
[34] zur Nedden, M. Epidemic of keratitis superficialis. Klin. M. f. Augenh., 1939, v. 101, pp. 567-569.
[35] ———. Keratitis superficialis. Klin. M. f. Augenh., 1939, v. 102, pp. 487-490.
[36] ———. Observations on 500 cases of epidemic keratoconjunctivitis. Klin. M. f. Augenh., 1940, v. 105, pp. 424-430.
[37] Schultze. Keratitis superficialis epidemica. Klin. M. f. Augenh., 1939, v. 102, p. 425.
[38] Behr, C. Kerato-conjunctivitis epidemica. Deutsche med. Woch., 1940, v. 66, p. 515.
[39] ———, and Zeissler, J. Etiology of epidemic keratoconjunctivitis. München med. Woch., 1940, v. 87, pp. 665-671.
[40] Meesmann, A., and Bachmann, W. Clinical observations and microbiologic findings in epidemic keratoconjunctivitis. Klin. M. f. Augenh., 1940, v. 105, pp 1-7.
[41] Goedbloed, J. Keratoconjunctivitis punctata superficialis. Ophthalmologica, 1940, v. 99, pp. 436-439.
[42] Jess, A. On a new infectious and epidemic inflammation of the cornea and conjunctiva (Munich disease). München. med. Woch., 1940, v. 87, pl. 2, p. 903.
[43] Meissner, W. Epidemic of nummular keratitis (Dimmer) in Bavaria. München med. Woch., 1938, v. 85, pp. 1939-1940.
[44] ———. Nature of epidemic occurring in Germany in 1938-39. Deutsche med. Woch., 1940, v. 66, pt. 1, pp. 517-521.
[45] Smitmans, F. K. Symposium on epidemic keratoconjunctivitis. Med. Klin., 1939, v. 35, pp. 235-237.
[46] Schwitalla, H. Epidemic of keratoconjunctivitis nummularis (Dimmer). Klin. M. f. Augenh., 1939, v. 102, pp. 491-500.
[47] Jancke, G. Mechanism of development of nummular keratoconjunctivitis epidemica. Klin. M. f. Augenh., 1940, v. 105, pp. 7-15.
[48] Nagel, A. Question of diphtheritic etiology of epidemic keratoconjunctivitis (1938). München. med. Woch., 1941, v. 88, pp. 216-218.

[49] Senger, W. Studies on a conjunctival disease of unknown etiology. München. med. Woch., 1938, v. 85, p. 1810.
[50] ———. Studies on a conjunctival disease of unknown etiology. München med. Woch., 1939, v. 86, p. 607.
[51] Ohm, W. Discussion Smitmans,[45] Med. Klin., 1939, v. 35, pp. 235-237.
[52] Gildermeister, E., and Peter, H. Etiology of epidemic keratoconjunctivitis; pseudodiptheria bacilli. München med. Woch., 1941, v. 88, pp. 213-216.
[53] Becker. On epidemic herpetic eye inflammations. Klin. M. f. Augenh., 1939, v. 102, p. 866.
[54] Frank, H. New epidemic form of keratoconjunctivitis (Munich disease). Med. Welt, 1941, v. 15, pp. 421-425.
[55] Marchesani, O. Epidemic of keratoconjunctivitis in 1938; review of the literature. Jahresk. f. Ärztl. Fortbild., 1940, v. 31, pp. 35-39.
[56] Roggenkämper. Therapy of epidemic keratitis nummularis, preliminary report. Klin. M. f. Augenh., 1940, v. 105, pp. 109-110.
[57] Scheerer, R. Epidemic keratoconjunctivitis. Klin. M. f. Augenh., 1940, v. 105, 110-111.
[58] Tertsch, R. Therapy of epidemic keratoconjunctivitis. Klin. M. f. Augenh., 1941, v. 106, pp. 84-86.
[59] Bartels, M., and Löns, M. Causative agent of epidemic keratoconjunctivitis. Klin. M. f. Augenh., 1941, v. 106, pp. 83-84.
[60] Salzmann, M. Keratitis in connection with herpes. Ber. ü. d. Versamml. d. Deutsche. Ophth. Gesellsch., 1928, v. 42, p. 303.
[61] ———. Keratitis nummularis (Dimmer). Arch. f. Ophth., 1934, v. 132, pp. 399-420.
[62] Aust, O. Keratitis nummularis (Dimmer). Arch. f. Ophth., 1933, v. 129, pp. 576-595.
[63] ———. Epidemic nummular keratitis. Zeit. f. Augenh., 1934, v. 82, p. 167.
[64] Ješe, L. Nummular keratitis. Klin. M. f. Augenh., 1936, v. 96, pp. 219-226.
[65] ———. Nummular keratitis. Klin. M. f. Augenh., 1938, v. 100, pp. 874-891.
[66] ———. Remarks on keratoconjunctivitis nummularis epidemica (Dimmer). Klin. M. f. Augenh, 1939, v. 103, p. 97.
[67] Székeley, J. Keratitis nummularis (Dimmer). Arch. f. Ophth., 1935, v. 134, pp. 184-188.
[68] Sácha, A. Keratitis nummularis (Dimmer). Arch. f. Ophth., 1933, v. 131, pp. 102-107.
[69] Pillat, A. Cited by zur Nedden,[36] Klin. M. f. Augenh., 1940, v. 105, pp. 424-430.
[70] Mulock Houwer, A. W. Keratitis nummularis (Dimmer). Nederl. Tijdschr. v. Geneesk., 1938, v. 82, pp. 4152-4156.
[71] Elwyn, H. Three cases of keratitis nummularis (Dimmer). Arch. of Ophth., 1935, v. 13, pp. 1119-1120.
[72] Chen, W. Y. Keratitis nummularis (Dimmer's disease). China Med. Jour., 1934, v. 48, pp. 682-690.
[73] Hobson, L. C. Acute epidemic superficial punctate keratitis. Amer. Jour. Ophth., 1938, v. 21, pp. 1153-1155.
[74] Viswalingham, A. Epidemic superficial keratitis in Malaya. Account based on keratitis which occurred in Selangor, one of federated Malay states from 1935-1938. Brit. Jour. Ophth., 1941, v. 25, pp. 313-324.
[75] Hamilton, J. B. Survey of superficial keratitis in Tasmania with record of mild epidemic. Brit. Jour. Ophth., 1941, v. 25, pp. 1-17.
[76] Holmes, W. J. Epidemic infectious conjunctivitis. Hawaiian Med. Jour., 1941, v. 1, pp. 11-12.
[77] Neame, H. The association of dendritic ulcer of the cornea and of superficial punctate keratitis with herpes facialis. Brit. Jour. Ophth., 1937, v. 21, p. 298.
[78] Nuel, J. P. Keratitis punctata superficialis. Arch. d'Opht., 1894, v. 14, pp. 145-163.
[79] Grüter, W. Experimental and clinical studies on the cause of herpes corneae. Ber. ü. d. Versamml. Deutsche. Ophth. Gesselsch., 1920, v. 42, pp. 162-167.
[80] ———. Virus of herpes. München. med. Woch., 1924, v. 71, pp. 1058-1060.
[81] Reichling, W. Discussion Smitmans.[45]
[82] Dresel, E. G. Discussion Jess.[42]
[83] Nuel, J. P. Keratitis punctata superficialis is a microbic disease. Arch. d'Opht., 1896, v. 16, pp. 725-734.
[84] Fradkine, J. Three cases of superficial keratitis punctata subepithelialis following influenza. Bull. et. Mém. Soc. Franç. d'Opht., 1932, v. 45, pp. 135-140.
[85] Wehrli, E. Histology of keratitis punctata superficialis (Fuchs), keratitis subepithelialis (Adler). Klin. M. f. Augenh., 1906, v. 44, pp. 224-236.
[86] Davis, W. T. Superficial punctate parenchymatous keratitis. Arch. of Ophth., 1942, v. 27, pp. 279-293.
[87] Cowan, A., and Cowan, T. H. Superficial punctate keratitis. Arch. of Ophth., 1938, v. 19, p. 709.

A NEW AND IMPROVED TECHNIQUE FOR THE CLOSURE OF CATARACT INCISIONS

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From a review of the literature on cataract surgery with reference to incisions and their closure, it is evident that whereas improvements have been made, none quite meets all the requirements of what might be termed the ideal procedure. The experienced ophthalmologist must conclude that, as in the surgery for glaucoma, all the methods of wound closure are still wanting in many respects: In some the suturing is not secure, permitting the wound to gape at the upper pole. This allows aqueous to escape, the anterior chamber to collapse, and prolapsis of the iris into the wound to occur. It also allows epithelium to grow into the wound and weaken the cicatrix. Certain types of incision make delivery of the lens a cumbersome, awkward procedure, while in still other procedures the tissues do not coapt in their exact relationship, or there are great difficulties in placing sutures after the globe has been opened.

During my surgical experience I have tried every mode of closure described, except that of using no support at all. None, however, seemed adequate until by varying, combining, and adding to the principles of several closures the desired result was obtained. The procedure that I have now been using for the past year has been extremely satisfactory, in my hands, regardless of the type of extraction I wished to perform. It is carried out in the following manner:

After the necessary preoperative preparation has been made the upper two fifths of the conjunctiva is incised at the limbus, leaving no conjunctival flap attached to the cornea (fig. 1 A), so that an area, approximately 1 mm. wide, is kept free of epithelium, between the incisions of the conjunctiva and the limbal section. This area extends around the whole incision and provides a narrow strip of denuded tissue on the corneal flap to which the conjunctiva can adhere, thus sealing the wound more rapidly. For incising the conjunctiva a moderately fine blunt scissors is used to nick the conjunctiva as close to the limbus as possible and then to continue the incision from this point in both directions. The conjunctiva is undermined for 6 to 8 mm. (fig. 1 B and C) or until it can be drawn down 3 to 4 mm. over the cornea without exerting traction on the tissue. This can be tested before the incision is made by grasping the conjunctiva with small tissue forceps and pulling it down over the contemplated incision. If this is not possible with ease more undermining of the conjunctiva should be done. All seeping of blood and bleeders are then controlled; the persistent ones may be stopped easily by touching them with the point of a heated hypodermic needle. After bleeding is controlled and with scleral fixation of the globe provided, the limbal fibers are split from 10:30 to 12 and from 12 to 1:30 on the iris dial. For this purpose a small cataract knife is used, with the blade held flat or parallel to the limbus fibers (fig. 2 A and B). At this part of the procedure care must be exercised so that the knife does not penetrate more than about one half of the scleral fibers. The knife may be gauged as to its depth just as the depth of a needle is gauged when scleral sutures are placed; however, if the outline of the blade is visible, the penetration has not gone too deeply. Frequently, in making

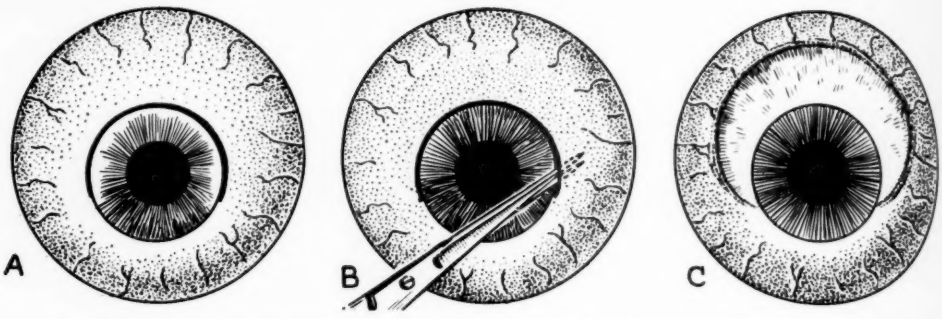

Fig. 1 (DeVaul). A, Incision of conjunctiva about limbus of cornea. B, Undermining of conjunctiva. C. Conjunctiva retracted after undermining, exposing the sclera.

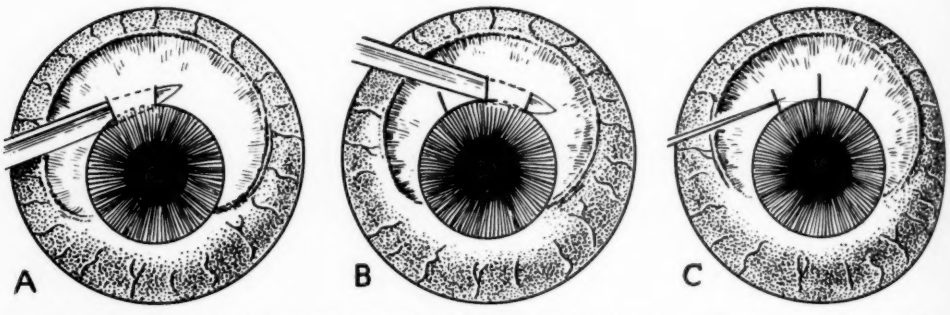

Fig. 2 (DeVaul). A and B, showing method of making limbo-scleral flaps. C, showing position of knife in dividing the flaps, so one portion is attached to sclera the other to the cornea.

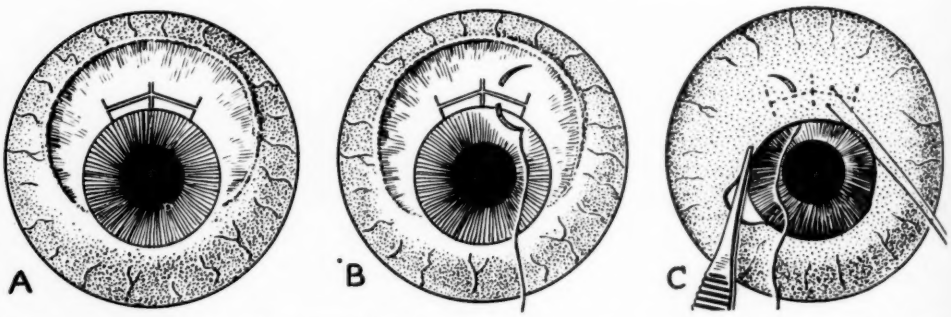

Fig. 3 (DeVaul). A, Flaps completed, ready for sutures. B, Inserting suture in flaps. C, First suture completed in flaps and conjunctiva. Second suture through flaps, needle passing through conjunctiva. First suture drawn taut, conjunctiva stretched over incision so exactly the same spacing between sutures can be obtained in conjunctiva as in flaps.

these flaps, I begin with the cutting edge of the knife facing the cornea and control the distance into the limbal tissue of the cornea with the cutting edge on the bevel of the blade, then rotate the knife through 180 degrees and point the cutting edge in the opposite direction to complete the procedure. These bridgelike flaps of scleral tissue are about 2 by 3 mm. in size. The same knife is then used to divide these flaps, by turning it at right angles to the globe with the cutting edge up, and with the point dividing the flap at about its midsection (fig. 2 C). This leaves a scleral flap on the globe and a scleral or limbal flap attached to the cornea about 1 by 3

mm. in size (fig. 3A). These flaps perform four important functions: They furnish dense scleral tissue for suturing the upper part of the wound. They also provide a method whereby the sutures can be securely laid before the section is made, and exactly the same spacing be obtained between the sutures in the cornea and in the sclera. This prevents buckling and distortion of the corneal tissue when the sutures are tied down. The flaps attached to the cornea overlap the upper one third to one half of the corneal section. They also produce a laminated closure of the upper part of the wound, which adds to the security of the closure. Sutures are laid in these flaps before the anterior chamber is opened (fig. 3 B and C); they may be placed as deep as the base, or at any point between it and the edge of the flap. I usually place them fairly deeply, providing approximately 1 mm. of scleral tissue for suture support that the thread would have to cut through before the wound could open and gape—a much firmer hold than could be obtained if placing of the sutures were attempted after the incision had been made.

A double-armed suture is easily inserted in these appendages, without fear of accident, and in such a manner that when drawn taut they will bring the corneal tissue into exact apposition (fig. 3 B and C). The suture is then carried up under the conjunctiva and brought through to the exposed surface 4 to 5 mm. behind the cut edge (fig. 3 C). The other needle is now carried through the conjunctiva to a point approximately 1½ mm. nearer the cut edge and directly below the previous suture (fig. 3 C and fig. 4). The suture is placed in the other scleral and corneal flaps in like manner, but before passing it through the conjunctiva the former suture is drawn taut and held by an assistant. This enables the operator to obtain exactly the same spacing between the sutures in the conjunctiva as in the scleral corneal flaps, so that when these are tied down the conjunctiva will be smooth and taut over the wound without any bulging or wrinkling (figs. 3 C and 5 B).

Some might ask why the lower suture is inserted through the conjunctiva at this stage instead of later when the section and delivery of the lens have been completed, especially since it necessitates making a double loop of sutures over the limbus through which the incision must be made. It is just this suture that to a large extent controls the corneal flap and returns it to its original position. If, after delivery of the lens, an accident were to occur with vitreous beginning to escape, and this suture were not in place, complete and immediate closure would be impossible. Thus the time element in placing these sutures, with vitreous spilling, might make the difference of an eye lost or an eye saved.

After the sutures are placed the conjunctiva is allowed to recede to its retracted position so as to be out of the way for the incision, iridectomy or iridotomy, and delivery of the lens (fig. 4). The thread between the scleral-corneal flaps is then drawn into a loop which is placed over the limbus of the cornea along with the loop of the lower thread. The nasal suture is placed over the nasal limbus, the temporal over the temporal limbus, so that the incision can be made and the knife pass between the threads of these loops (fig. 4). The main sutures are thus in place before the globe is opened.

The incision is made in the classical manner, except that if the conjunctiva has been incised properly the knife enters, emerges, and follows the limbus about 1 mm. from the incised edge of the limbal conjunctiva (fig. 4). As it reaches the upper limbus the blade is gauged to come out beneath the base of the flaps left on

the cornea (fig. 4). This eliminates the necessity of turning the knife sharply forward in completing the incision, as is necessary in some other techniques. The incision is completed straight along the limbus and the tissues are cut clear through on a bevel instead of directly

Fig. 4 (DeVaul). Sutures in place, loops formed over limbus, conjunctiva retracted. Puncture and counter puncture of knife. Dotted line shows line of section. Dark line of limbus corresponds to line of conjunctival incision. Distance between two lines denuded for adherence to conjunctiva when carried down over incision in closure.

perpendicular to the corneal surface at the upper pole of the section, as is frequently necessary with other types of incisions. The iridectomy or iridotomy and the procedure for extraction of the lens are carried out as in any other type of incision. After extraction, gentle traction on the sutures draws the corneal flap into position and pulls the conjunctiva down over the upper part of the incision (figs. 3 C and 5 A and B). As a rule, however, to avoid distorting the cornea, an assistant draws the conjunctiva down with forceps until the sutures are tied. When the tissues are in place and before the tying of the sutures, the iris can be replaced and the pillars freed. After the upper sutures are tied, conjunctival sutures are placed at approximately the 4- and the 8-o'clock positions, and the conjunctival flap is drawn down over the lateral edges of the incision (fig. 5 B). The completed closure then presents a laminated wound sutured in dense scleral tissue with limbal flaps overlapping the upper part of the section and with conjunctiva drawn over and tied in with the sutures above as well as covering the lateral edges of the wound (fig. 5, A and B).

The advantages in using this procedure are numerous: A closure of maximum security is obtained. The upper part of the section is overlapped with scleral tissue as well as with conjunctiva. Exactly the same spacing is obtained between the sutures on the corneal and scleral sides of the wound, so that there is no buckling of the corneal tissues and no gaping of the wound. The tissues are returned and maintained in exact apposition and relationship with those from which they were separated. By this method the sutures can

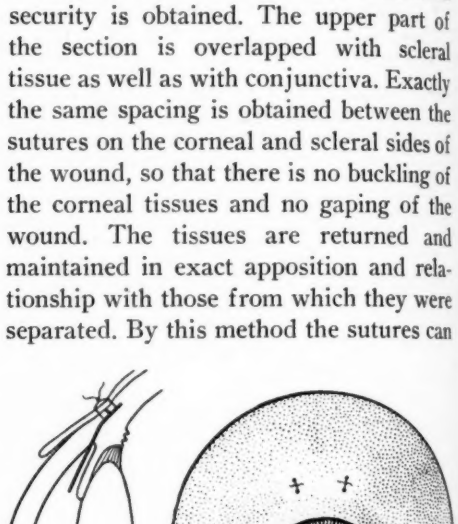

Fig. 5 (DeVaul). A, Meridional section showing position and lamination of tissues in closure. B, completed closure with conjunctiva covering entire incision. Sutures tied, no suture touching cornea.

be placed before the anterior chamber is opened, and the wound can be quickly and adequately closed in case of an accident and escape of vitreous. It provides protection for the entire wound instead of

just the upper pole, since it is completely covered with conjunctiva that protects not only the suture holes but the entire wound. There is no inverting of the tissues and gaping of the inner margins of the wound, which occur when the upper part of the section is cut at almost right angles to the corneal surface and the superficial layers of the cornea and sclera are used for suture support. This is especially apt to occur in placing mattress sutures when the bite of the suture is on either side of the incision and the threads over the incision are anterior to the corneal substance; as a result the iris may become incarcerated and the outcome is an anterior synechia. Since with the aforedescribed procedure the tissues are laminated in the closure, and the entire section is cut on a bevel instead of transverse to the surface at the upper part of the section, the effect is that of a valve, preventing the escape of aqueous (fig. 5 A). Moreover the wound is more quickly sealed because the conjunctiva covers denuded tissue on each side of the incision (fig. 4). Since no conjunctival flap is attached to the cornea a denuded area of limbus about 1 mm. wide remains around the whole incision. When this and the flaps above are covered with conjunctiva they adhere very rapidly, thus sealing the anterior chamber more quickly than when dense tissues alone must cohere before sealing takes place. The lateral edges of the wound are protected by the conjunctival flap which also presses the cut surfaces together holding them in closer apposition, so that sealing of the dense tissues is also more rapid. This renders it almost impossible for the anterior chamber to empty and prolapses of the iris to occur.

Similar scleral flaps can be used from the 9- to the 10:30-o'clock and from the 1:30- to the 3:00-o'clock positions, and the conjunctiva tied down in their sutures, as at the upper part of the wound. I have used them thus on three or four occasions, but it complicates the reposition of the iris pillars and makes many sutures to keep straight.

There is another definite advantage to placing the conjunctiva as aforedescribed, although it does not add to the security of the cataract incision. If all sutures are cut quite short, the ends do not drag over the corneal tissue and thus postoperative irritation is prevented. It has been particularly interesting to note the absence of corneal irritation in these cases, even though sutures have remained in place for 14 days at the upper part of the wound. The firmness with which they hold was also demonstrated here, in that they had not cut through the scleral bites.

Since the tissues of the wound are laminated in the closure—that is, the limbal flap of the cornea overlaps the scleral bevel and is itself overlapped by the conjunctiva—all possibility of epithelium growing into the wound and the scar becoming thinned is eliminated. This applies to the sides as well as to the upper portion of the incision.

The procedure herein outlined requires somewhat more skill, a greater knowledge of mechanics, and more accurate execution of those mechanics than many of the other procedures. However, it is submitted that once the technique is mastered, fewer ophthalmologists will be content to leave their cataract incisions inadequately secured.

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VISUAL PROBLEMS: CERTAIN ASSUMPTIONS AND DATA*

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It is assumed that a binocular refraction is done for the purpose of studying the equilibrium in the binocular functions of accommodation and convergence. Lenses may be sufficient to reëstablish a desirable relationship between accommodation and convergence. In some cases, however, the lens correction—the need of which has been manifested by one function—may interfere with these relationships and thereby result in visual inefficiency, and subsequent discomfort, visual concessions, or a cessation of near-point activities. In short, the individual must secure adjustment by some means. For example, spheric and/or cylindric lenses may be required to establish, or may be accepted without diminishing, clearness of seeing, but the resultant change in posture of accommodation may not be compatible with changes induced in the associated function of convergence. And again, prism lenses may appear to be essential to maintain singleness of vision, but they may induce undesirable changes in the associated function of accommodation. In summary, a lens formula is supplied to establish an equilibrium in the binocular functions, or to balance the dynamic relationships between accommodation and convergence.

When placed before the eyes, plus and minus lenses change posture of accommodation. Plus lenses inhibit accommodation in the sense that they alter the posture of the accommodative mechanism as though the stimulus had been moved away; minus lenses stimulate accommodation in the sense that they alter the posture of the accommodative mechanism as though the stimulus object had been brought nearer. By habitual association, or redintegration, like changes are induced in convergence. When base-out prisms are introduced before the eyes, convergence is stimulated in the sense of changed posture; when base-in-prism power is introduced, convergence is inhibited in the sense of changed posture. Through association, prisms used to stimulate or inhibit convergence tend to cause like changes in accommodation. However, delays—or areas of tolerance, or compensation—are learned to protect one response from changes in relationships between neurologic patterns. This partakes of the nature of a "delayed redintegration," a cortical process contributing to integrated behavior.

PURPOSES OF THIS REPORT

The chief purposes of this report may be summarized as follows: (1) To summarize certain principles and assumptions basic to a psychophysiologic approach to the analysis of visual problems. (2) To describe and appraise certain visual problems of children at the fifth-grade school level.

PURPOSES OF AN ANALYSIS OF BINOCULAR VISION

In general, it is assumed that a refraction is made to appraise *binocular* vision at certain near points and at distance in order to identify possible causes of com-

* From the Department of Education and Psychology, The Reading Clinic, The Pennsylvania State College, School of Education, Emmett A. Betts research professor and director of The Reading Clinic. Special acknowledgements for help on this Reading Clinic project are due to A. Sterl Artley, Agnes Sutton Austin, Bonnalee Brown, C. R. Carpenter, J. E. DeCamp, Supt. J. G. Everard, A. M. Skeffington, and Mary Jane Skeffington (M.D.).

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plaint and/or lack of visual achievement. The purposes of an analysis of binocular vision may be described briefly as follows: (1) To determine the integrity of visual skills. Stated negatively, to ascertain the achievement level at which the visual skills have tended to disintegrate (for example, at monocular, binocular, or possibly higher levels). (2) To define the nature of possible psychophysiologic interference in the binocular functions (for example, as evidenced in phorias, ductions, accommodative amplitude, and the like). (3) To identify compensations and/or concessions (surrenders) (for example, pseudomyopia, suppression, lowered visual acuity, amblyopia, lowered stereopsis, and the like). (4) To identify the function which is the primary source of the visual problem (for example, a greater change in the patterns of convergence or of accommodation). (5) To identify *tendencies* toward dysfunction in the accommodative-convergence relationships (this for prophylaxis).

Assumptions regarding binocular vision

In order to approach the problem of visual analysis in terms of data and conclusions reached by scholars in psychophysiology and neurophysiology, it is desirable to review certain propositions that appear to be acceptable. Unprofitable argumentation ensues when premises are not identified. A discussion of problems in binocular vision soon leads to the use of higher-order abstractions, because notions are based on inferences. In so far as possible, the assumptions herein are discussed in descriptive language. It will be noted that relationships, or patterns of seeing, rather than isolated responses and findings receive major consideration. The following assumptions, therefore, are stated with this in mind:

I. The stimulus to both accommodation and convergence primarily is reflected light. Seeing is mental interpretation of that reflected light. (Visual acuity depends to a degree upon the background of the target.)

II. Lenses change postural set of the seeing mechanism by redirecting (or refracting) light.

A. Spheres change postural set of accommodation.

1. A plus sphere inhibits (or "relaxes") accommodation. A postural set of accommodation is achieved, as though the target has been moved away from the eyes.

2. A minus sphere stimulates accommodation. A postural set of accommodation is achieved, as though the target has been moved nearer to the eyes.

B. Prisms change postural set of convergence.

1. Prisms introduced base-in before a pair of eyes inhibit convergence. A postural set of convergence is achieved, as though the target has been moved away from the eyes.

2. Prisms introduced base-out before a pair of eyes stimulate convergence. A postural set of convergence is achieved, as though the target has been moved nearer to the eyes.

III. Within measurable limits, the postural set of one mechanism (that is, accommodation or convergence) can be altered by means of lenses without reflexly (through redintegration) producing a change in the postural set of the other mechanism.

A. A certain amount of accommodation (that is, convergent accommodation) is associated with convergence.

B. A measurable amount of accommodation (that is, relative accommodation) normally is *free* of association with convergence. A certain amount of hyperopia

—or accommodation free of association with convergence—is desirable. For example, when less than approximately three fourths of one diopter of hyperopia is found at distance the individual may continue through emmetropia to myopia. This indicates a *tendency* toward loss of hyperopic reserve.

*C. Beyond a measurable inhibition, in*creased stimulation to accommodation produces increased stimulation to convergence; and conversely.

D. A certain amount of convergence (that is, accommodative convergence) is associated with accommodation.

*E. A measurable amount of converg*ence (that is, relative convergence) is free of association with accommodation. Approximately four to six prism diopters of exophoria at the near point (16 inches) is desirable as a reserve to protect convergence from changes in relationships between functions.

IV. ACCOMMODATION, OR FOCUS, IS PRImarily under autonomic control. Posture of accommodation is achieved largely through smooth-muscle action.

V. CONVERGENCE, OR TRIANGULATION, IS primarily under central, or somatic, control and is achieved largely through striped muscles.

VI. SEEING INVOLVES, IN ADDITION TO other things, *learned* relationships between accommodation and convergence. Visual-analysis findings provide indexes of the efficacy of these learned relationships.

VII. NEITHER MONOCULAR NOR BINOCULAR far-point findings can be used to predict accurately binocular near-point responses.

VIII. PARALLELISM AT INFINITY IS A DYnamic state (that is, characterized by a state of tonus), as are all other postural sets.

IX. VISUAL REËDUCATION, THROUGH training, produces changes in patterns of seeing—measured through relationships between functions—rather than changes in structure (such as lengthening or shortening the eyeball) or in the "strength" of the muscles. Visual reëducation through orthoptics has possibilities beyond those involved in the correction of squint.

X. THE THEORY OF THE ELONGATED EYEball neither adequately describes nor entirely accounts for myopia. This also throws into question the short-eyeball hypothesis of hyperopia.

XI. INTERFERENCES IN THE BINOCULAR functions—probably manifestations of the arousal of contradictory reflex arcs or lack of proper integration—may account to a degree for discrepancies between responses (described by means of artificial test findings) and the expecteds set up in terms of physical optics. An interference is a manifestation of a breakdown in relationships between visual functions.

A. In sustained seeing activities, one function (accommodation or convergence) may "fatigue" before the other; that is, greater change takes place in the neural pattern of organization of one function than in the other for continuation of both singleness and clearness in the visual act. This increased change of pattern in one function may be continued to the point at which the reserve (hyperopic reserve or exophoric reserve, as the case may be) is depleted. Interferences may be brought about by accommodative pattern change or adductive pattern change.

B. Reversal phenomena may be ob-

served in some cases when the need for unequal stimulation to the binocular functions (that is, the inhibition of one function) has been reduced by means of lenses. For example, in these situations, minus lenses may increase exophoria and plus lenses may increase esophoria.

C. In order to achieve an equilibrium between accommodation and convergence, the following general types of conditions merit consideration:

1. The correction at distance is acceptable at near points. In short, the pattern change in accommodation is at the same "ratio" at all seeing points.

2. More plus and less minus is acceptable at a near point of application than at the far point. Briefly, there is more neurologic-pattern change in accommodation at near point than at the far point.

3. Less than the full plus correction revealed by the tests is acceptable at both near and far points. That is, the full lens correction would set up a new interference in the seeing pattern and, therefore, cannot be prescribed until desirable relationships can be established by means of visual reëducation (or training).

4. Corrections may involve variations and combinations of the aforementioned three general types of syndromes. In addition, toxic interferences may be manifested in the syndrome.

D. In general, the prescribed lens should not take up more than the amount of accommodation free of association with convergence. Since near-point seeing is done under somewhat different neurologic, psychologic, and external conditions than at distance, it is desirable to take a manifest finding at near point that is comparable to the far-point manifest. At the near point, a negative relative accommodation does not provide data comparable to far-point manifest. (A modification of the Jackson cross-cylinder presbyopic technique was used to secure nearpoint manifest findings for this study.)

XII. ALTHOUGH PATTERNS OF SEEING ARE *learned,* the physical mechanism is a part of the human body and, therefore, reflects changes in the general tonus of the organism. (In the writers' judgment, this frequently has received insufficient consideration in the study of visual problems.)

XIII. LENSES AND/OR VISUAL REËDUCATION may be used to establish an equilibrium in the relationships between visual functions. In some cases, systemic disturbances and imbalances may be important factors in the situation.

*A. This equilibrium exists in the neuro*logic patterning rather than in the postural set of the mechanism. In short, postural set is a symptom, or a manifestation, of neurologic organization to satisfy the seeing needs of the organism. In a dynamic state, posturing reflects changes taking place in the nervous system.

*B. Indexes to equilibrium may be se*cured by means of duction findings and positive and negative relative-accommodation findings.

1. Base-out to blur-out at a near point indicates the amount (measured in prism diopters) of stimulation to convergence that can be tolerated without reflexly stimulating accommodation.

2. Base-in to blur-out at a near point indicates the amount (measured in prism diopters) of inhibition in convergence that can be tolerated without reflexly inhibiting accommodation.

3. With fixation at a near point, the addition of minus spheres to blur-out indicates the amount (measured in diopters) of stimulation to accommodation that can be tolerated without reflexly stimulating convergence.

4. With fixation at a near point, the

addition of plus spheres to blur-out indicates the amount of inhibition to accommodation that can be tolerated without reflexly inhibiting convergence.

(Note: Since these four findings are measures of *learned* associations and have significance largely in terms of relationships, they are taken at near point. For example, divergence at the far point is not *learned* because the organism has no need for it.)

XIV. A PHORIA FINDING PROVIDES AN INdex to the tendency to change postural set of convergence.

XV. DUCTIONS PROVIDE INDEXES TO learned associations between convergence and accommodation rather than to the strength of the extrinsic muscles. (The full significance of ductions as psychophysiologic factors in vision needs to be established through further investigation.)

A. Addition of prism power to first blur, or possibly blur-out, gives a measure of the amount of inhibition in accommodation.

B. Addition of prism power from blur to diplopia gives a measure of the degree to which accommodation and convergence are associated.

C. Reduction of prism power from diplopia to recovery of single binocular vision gives a measure of the "desire" for binocularity.

If these assumptions are proved, experimentally, to be valid, then certain possibilities suggest themselves: First, the analysis of near-point visual problems can be made systematically and with greater assurance. Second, a basis is afforded for visual reëducation through both the prescribed lenses and training. Third, rejectees from military service (such as aviation) and industry presenting functional vision problems can be rehabilitated. Fourth, the visual efficiency of all workers with functional-vision problems can be improved, and in some cases performance may be expected to be raised to higher levels. Fifth, the *prevention* of functional-seeing difficulties can be studied on a broader basis. All these possibilities should be investigated by means of case study, normative survey, and correlation methods.

In the analysis of visual needs, available instrumentation and refraction techniques introduce certain limitations. First, most of the test situations introduce highly artificial seeing conditions. Second, the reliabilities of the test situations are in need of further investigation. Third, the controls (for example, the targets) themselves make it difficult to evaluate findings taken by different investigators. While these and other limitations may be for the moment obstacles meriting careful consideration, the visual-analysis findings do permit a type of investigation subject to fairly rigorous scientific control.

Sequence of visual analysis

Chart 1 is a summary of the visual-analysis sequence used in this study. Since the type of control target used is undoubtedly a significant factor in the results obtained, a brief description of each target is included. Some of the findings were included in this study for experimental purposes. In addition to the diagnostic data secured, screening tests (the Visual Sensation and Perception Tests of the Betts Ready-to-Read Battery) were administered. Before initiating this analysis routine, a case history, including symptoms, was taken.

Limitations of study

Some of the chief limitations of this study may be briefed as follows:

1. *Population.* The entire fifth-grade population, 126 pupils, of the Hunting-

CHART I

SUMMARY OF VISUAL-ANALYSIS SEQUENCE

Test	Distance	Target
1. Visual acuity (uncorrected and with correction, if any)	20′	Projected Snellen chart
2. Visual acuity (uncorrected and with correction, if any)	14″	A.M.A. reading card
3. Rotations and versions	18″	Ophthalmoscope bulb
4. Fixations, from distance to near, and vice versa	20′ and 4″	Projected Snellen chart at 20′ and ophthalmoscope bulb at 14″
5. Lateral fixation	14″ and at extremes of 180° versions	Two pencil points
6. Near point of convergence		Ophthalmoscope bulb
7. External ocular examination		
8. Interpupillary distance		
9. Habitual lateral phorias		Smallest recognizable letters on:
	a. 20′	a. Projected Snellen chart
	b. 16″	b. Reduced Snellen chart
10. Retinoscopic examination	Fixation at:	Smallest recognizable letters on:
	a. 20′	a. Projected Snellen chart
	b. 20″	b. Smallest recognizable letters on chart attached to retinoscope
	c. 40″	c. Same as "b"
11. Manifest with resultant V.A.	20′	Projected Snellen chart
12. Lateral phoria through manifest	20′	Projected Snellen chart: Vertical column of smallest recognizable letters
13. Prism convergence through manifest: first blur, break, and recovery	20′	Same as no. 12
14. Prism divergence through manifest: break and recovery	20′	Same as no. 12
15. Vertical phoria through manifest	20′	Horizontal line of projected Snellen chart
16. Vertical ductions through manifest	20′	Same as no. 15
17. Lateral phoria through manifest	16″	Smallest recognizable letters on reduced Snellen chart
18. Dissociated cross-cylinder	16″	Cross-cylinder grid chart with reduced illumination to avoid prismatic color aberration
19. Lateral phoria through dissociated cross-cylinder findings	16″	Same as no. 18
20. Binocular cross-cylinder	16″	Same as no. 18
21. Lateral phoria through binocular cross-cylinder findings	16″	Smallest recognizable letters on reduced Snellen chart
22. Prism convergence through manifest: blur-out, break, and recovery (Note: No more minus used than was habitually worn)	16″	Same as no. 21
23. Prism divergence through manifest: blur-out, break, and recovery (see note on no. 22)	16″	Same as no. 21
24. Vertical phoria through manifest	16″	Horizontal line and dot of Sheard
25. Vertical ductions	16″	Same as no. 24
26. Amplitudes of accommodation: O.D., O.S., O.U.	13″	A group of small letters (0.62 M type)
27. Relative accommodations: positive and negative	16″	Smallest recognizable type on reduced Snellen chart
28. Cycloplegic (Homatropine 5-percent solution and paredrine solution)	20′	Projected Snellen chart

don, Pennsylvania, Public Schools was used. Complete data were secured in 109 cases.

(a) The average chronologic age was 11 years 1.5 months. (b) The average I.Q. was 104.2±14.1.

2. *Time of examination.* The pupils

TABLE 1

SUMMARY OF REFERRALS ON VISUAL-ACUITY TESTS

	f*	Percent
Non-referral on near and far V.A.	81	71.7
Referral on near and far V.A.	18	15.9
Referral on far point V.A. only	12	10.6
Referral on near point V.A. only	2	1.8
Total	113	100.0

f = frequency, or number of cases.

had been in school most of the year and therefore the effect of school tasks upon visual adjustments may have been greater than after a prolonged vacation period. Second, the high incidence of conjunctivitis and blepharitis (largely low grade) found *may* have been partly attributed to the season of the year.

3. *The binocular examination.* The visual analysis routines—both diagnostic and screening—were developed primarily for the study of *binocular* vision problems.

TABLE 2

SUMMARY OF RELATIONSHIPS BETWEEN LATERAL PHORIA FINDINGS

Finding	Distance	f*	r†	P.E. of r‡
Habitual and induced through manifest	20′	116	0.65	±0.036
Habitual and induced through manifest	16″	115	0.76	±0.025
Habitual and induced through dissociated cross-cylinder finding	16″	113	0.66	±0.036
Habitual and induced through binocular cross-cylinder finding	16″	113	0.77	±0.026
Induced through dissociated cross-cylinder finding and binocular cross-cylinder finding	16″	115	0.80	±0.023
Habitual near and far	20′ and 16″	115	0.39	±0.053
Induced through subjective near and far	20′ and 16″	116	0.46	±0.031

* f = number of cases.
† r = correlation (based on the Pearson Product Moment formula).
‡ P.E. of r = probable error of r.

TABLE 3

SUMMARY OF RELATIONSHIPS BETWEEN RETINOSCOPIC FINDINGS

Finding	Eye	r	P.E. of r
"Static" with dynamic at 20″	O.D.	0.93	±0.008
"Static" with dynamic at 20″	O.S.	0.94	±0.007
"Static" with dynamic at 40″	O.D.	0.92	±0.010
"Static" with dynamic at 40″	O.S.	0.94	±0.007
Dynamic at 20″ with dynamic at 40″	O.D.	0.92	±0.010
Dynamic at 20″ with dynamic at 40″	O.S.	0.98	±0.003

were examined during March, April, and May. This has at least two possible significant implications: First, the pupils

4. *The following criteria,* admittedly inadequate, were used to determine the need for a lens correction:

(a) An esophoria of 5$^{\Delta}$ or more through the manifest at 16 inches. (b) Less than 20/20 in either eye. (c) Less than 14/14 in either eye. (d) Astigmatism of 0.75 diopter or more. (e) Simple hypermetropia of 2.00 diopters or more; or of 0.75 diopter or more with symptoms unless contraindicated by exophoria. (f) Acceptance of any amount of minus lens (binocularly). (g) Anisometropia of

0.75 diopter or more. (h) Hyperphoria of 2$^{\Delta}$ or more at near or far. (i) Heterotropia.

(Note: Criteria are being established to determine the need for visual reëducation through training among the subjects in both the "glasses" and the "no glasses" categories.)

Results

Twenty-eight and three-tenths percent of the population had less than 20/20 visual acuity in one or both eyes at distance and/or less than 14/14 visual acuity in one or both eyes at near. Subjects were put in the "referral to a specialist" category when less than 20/20 and/or 14/14 visual acuity in one or both eyes was found. These data are summarized in table 1.

TABLE 4

SUMMARY OF RELATIONSHIPS BETWEEN LATERAL-DUCTION BREAK AND RECOVERY FINDINGS (116 cases)

Finding	Distance	r	P.E. of r
Adduction	20′	0.25	±0.06
Abduction	20′	0.55	±0.04
Adduction	16″	0.56	±0.04
Abduction	16″	0.38	±0.05

TABLE 5

SUMMARY OF RELATIONSHIPS BETWEEN LATERAL-DUCTION FINDINGS (116 cases)

Finding	r	P.E. of r
Base-out break: Far vs. near	0.48	±0.05
Base-in break: Far vs. near	0.46	±0.05
Base-out recovery: Far vs. near	0.42	±0.05
Base-in recovery: Far vs. near	0.31	±0.06

TABLE 6

SUMMARY OF VERTICAL-DUCTION FINDINGS

Finding	Eye	Distance	f	Break			Recovery		
				M.	S.D.	S.E. of M.	M.	S.D.	S.E. of M.
Supra	O.D.	20′	112	2.78	0.84	0.08	1.17	0.43	0.04
Infra	O.D.	20′	112	2.04	0.73	0.07	0.94	0.42	0.04
Supra	O.S.	20′	112	2.55	0.82	0.08	1.20	0.47	0.04
Infra	O.S.	20′	112	2.15	0.91	0.09	0.98	0.48	0.05
Supra	O.D.	16″	113	3.37	1.47	0.14	1.62	0.87	0.08
Infra	O.D.	16″	113	2.70	1.53	0.14	1.31	0.94	0.79
Supra	O.S.	16″	113	3.21	1.58	0.15	1.66	0.93	0.09
Infra	O.S.	16″	113	2.52	1.58	0.15	1.21	0.76	0.07

M = mean; S.D. = standard deviation; S.E. of M. = limits on each side of the obtained mean within which the true mean probably lies.

Table 2 is a summary of the relationships between lateral-phoria findings.

Using the Pearson Product Moment technique, a coefficient of correlation (r) was determined for each pair of retinoscopic findings. Table 3 is a summary of these data.

Relationships between duction findings are summarized in tables 4 and 5.

Table 6 is a summary of the vertical-duction findings.

The Pearson Product Moment formula was used to determine the relationship between the unfused, or dissociated, cross-cylinder (gross) findings at 16 inches and

TABLE 7

SUMMARY OF RELATIONSHIPS BETWEEN DYNAMIC RETINOSCOPIC FINDINGS AT 20″ AND UNFUSED CROSS-CYLINDER FINDINGS AT 16″ (115 cases)

Eye	r	P.E. of r
O.D.	0.87	±0.015
O.S.	0.80	±0.023

the dynamic retinoscopic findings at 20 inches. These data are summarized in table 7.

A summary of the gross-sphere findings taken by three techniques is presented in table 8. These are gross or "raw" findings.

Table 9 is a summary of the relationships between manifest and cycloplegic findings.

TABLE 8

SUMMARY OF DISTANCE SPHERE FINDINGS

Finding	f	M
Total "static" retinoscopic findings	118	0.70
Total manifest findings	118	0.47
Total cycloplegic findings	115	1.10
"Static" retinoscopic plus findings	118	0.97
Manifest plus findings	118	1.05
Cycloplegic plus findings	115	1.39
"Static" retinoscopic minus findings	118	1.21
Manifest minus findings	118	1.22
Cycloplegic minus findings	115	1.47

Table 10 is a summary of the results of the data on functional and cycloplegic findings taken for the purposes of this study.

SUMMARY OF RESULTS

1. *Symptoms.* Forty-three percent of the population reported ocular discomfort or inability to see clearly at all working distances. Approximately 70 percent of the complaints involved headaches, eye aches, blurred vision, tearing, and burning. In practically all cases interferences were found in the binocular functions that justified the complaints.

2. *Incidence of previous correction.* Twenty-five percent of the population had previously received the benefit of some type of "eye" examination by a specialist. Thirteen percent were wearing corrections at the time this study was initiated.

3. *Visual acuity.* Approximately 28 percent of the population was referred on the basis of near and far visual-acuity findings. Twenty-six percent of the population was referred on the basis of the three visual-efficiency slides of the Betts tests. Twenty-five percent of the population evidenced unequal vision acuity. Nine and nine-tenth percent of the subjects were unable to achieve 20/20 or better visual acuity in one or both eyes through the manifest.

4. *Ocular motility.* Approximately 10 percent of the subjects evidenced faulty ocular motility. No paralyses nor pareses were detected.

5. *Near point of convergence.* The mean near point of convergence was 4.8 ± 0.25 cm. Approximately 10 percent of the subjects showed a near point of convergence beyond 8 cm.; 12.5 percent, beyond 7 cm.

6. *Pathology.* Less than 1 percent evidenced intraocular pathology (in this case, disseminated choroiditis); 2 percent, tropias; 21.5 percent, blepharitis and/or conjunctivitis; and there was one case each of ptosis and corneal opacity.

7. *Interpupillary distance.* The P.D.'s ranged from 54 to 66 mm., with a mean of 59.9 ± 2.48.

8. *Phorias.* A fairly low relationship was found between near-point and far-point lateral-phoria findings. In regard to vertical phorias, 93 percent of the subjects were orthophoric at distance; 90 percent, at near.

9. *Retinoscopic findings.* There appears to be a high relationship between the retinoscopic findings. Ten percent of the

TABLE 9

SUMMARY OF RELATIONSHIPS BETWEEN MANIFEST AND CYCLOPLEGIC FINDINGS

Eye	r	P.E. of r
O.D.	0.88	±0.014
O.S.	0.85	±0.018

TABLE 10

SUMMARY OF CERTAIN FUNCTIONAL AND CYCLOPLEGIC FINDINGS

	f	M	S.D.	S.E. of M.
1. Near-point of convergence	121	4.79 cm	0.25	0.02
2. Habitual lateral phorias				
At 20 feet	116	0.09 Exo	2.57	0.24
At 16 inches	115	2.48 Exo	4.75	0.44
3. Induced lateral phorias				
At 20 feet through manifest	117	0.19 Exo	2.27	0.21
At 16 inches through manifest	116	2.81 Exo	1.71	0.16
At 16 inches through dissociated cross-cylinder findings	115	5.84 Exo	5.30	0.49
At 16 inches through fused cross-cylinder findings	115	5.66 Exo	4.44	0.41
4. Vertical phorias through manifest				
At 20 feet	115	0.02	0.25	0.02
At 16 inches	116	0.004	0.57	0.05
5. Prism convergence (adduction)				
Blur: Distance	116	7.44	2.55	0.24
Break: Distance	116	21.22	5.83	0.54
Recovery: Distance	116	7.19	4.97	0.46
Blur: Near	116	18.25	6.25	0.58
Break: Near	116	21.66	5.61	0.52
Recovery: Near	116	6.40	6.58	0.61
6. Prism Divergence (abduction)				
Break: Distance	116	7.10	3.20	0.30
Recovery: Distance	116	3.29	2.19	0.20
Blur: Near	116	17.95	4.45	0.41
Break: Near	116	21.52	3.77	0.35
Recovery: Near	116	12.47	6.44	0.60
7. Vertical ductions: distance				
Supraduction				
Break: Right	112	2.78	0.84	0.08
Recovery: Right	112	1.17	0.43	0.04
Break: Left	112	2.55	0.82	0.08
Recovery: Left	112	1.20	0.47	0.04
Infraduction				
Break: Right	112	2.04	0.73	0.07
Recovery: Right	112	0.94	0.42	0.04
Break: Left	112	2.15	0.91	0.09
Recovery: Left	112	0.98	0.48	0.05
8. Vertical ductions: near				
Supraduction				
Break: Right	113	3.37	1.47	0.14
Recovery: Right	113	1.62	0.87	0.08
Break: Left	113	3.21	1.58	0.15
Recovery: Left	113	1.66	0.93	0.09
Infraduction				
Break: Right	113	2.70	1.53	0.14
Recovery: Right	113	1.31	0.94	0.79
Break: Left	113	2.52	1.58	0.15
Recovery: Left	113	1.21	0.76	0.07
9. Retinoscope				
Fixation, 20 feet	118	+0.70	0.97	0.06
Fixation, 20 inches	118	+1.91	0.88	0.06
Fixation, 40 inches	118	+1.36	0.97	0.06
10. Subjective				
Spherical component	121	+0.42	1.15	0.02
Cylindrical component	121	−0.21	0.21	0.04
11. Cycloplegic				
Spherical component	115	+1.10	1.37	0.09
12. Cross-cylinder				
Dissociated	115	+1.78	0.98	0.07
Binocular	115	+1.44	0.98	0.07
13. Amplitude of accommodation				
O.D.	116	11.69	2.67	0.25
O.S.	116	11.66	2.64	0.24
O.U.	115	8.37	2.76	0.26
14. Positive relative accommodation	115	4.84	2.34	0.22
15. Negative relative accommodation	114	2.16	0.63	0.06

subjects evidenced myopia. It appears that "hyperopia" rather than "emmetropia" is the "norm" at this age level.

10. *Manifest findings.* Approximately 12 percent of the subjects were myopic at distance in one or both eyes. Thirty-seven percent accepted an astigmatic correction. Astigmatism with the rule was predominant.

11. *Ductions.* More than one half of the subjects reported blur before break. Relationships between near-point and far-point duction findings were fairly low.

The means of the vertical-duction break findings ranged from 2.04 to 3.37; for the recovery findings, from 0.94 to 1.66. In general, the supraduction findings tended to be higher than the infraduction findings.

12. *Cross-cylinder findings.* There appears to be a fairly high relationship between the gross cross-cylinder findings taken at 16 inches and the dynamic retinoscopic findings taken at 20 inches. The dissociated cross-cylinder findings tended to be higher than the binocular findings. Slightly higher exophoria findings were obtained through the dissociated cross-cylinder findings than through the binocular cross-cylinder findings.

13. *Amplitude of accommodation.* The amplitude of accommodation (O.U.) ranged from 3.25 to 15.75 diopters. The binocular findings tended to be lower than the monocular findings. The mean amplitudes were: O.D., 11.7; O.S., 11.7; O.U., 8.4.

14. *Relative accommodation through the manifest at 16 inches.* Using the Pearson Product Moment formula, an r of 0.02 ± 0.06 was obtained between the positive and negative relative accommodation findings. The mean positive relative-accommodation finding was 4.8 ± 2.34; the mean negative relative-accommodation, 2.16 ± 0.63.

15. *Cycloplegic findings.* In general, there was a fairly high relationship between manifest and cycloplegic findings. No subject accepted minus sphere on the manifest and plus sphere on the cycloplegic.

16. A total of 62.4 percent were found to be in need of lens corrections. Approximately one third of the lens corrections would have been prescribed for near-point seeing activities only.

Conclusions

The findings of this study indicate clearly the need for additional studies on the seeing problems of individuals at various age levels. These problems should be defined by means of comprehensive visual-analysis techniques. Studies reported heretofore have been cursory in nature.

If the findings reported herein are verified by subsequent studies, then serious thought should be given to preventive measures. It may become necessary to appraise the near-point seeing tasks imposed upon elementary school children. Sustained reading activities may produce visual inefficiency, especially among school children.

Evidences of toxic conditions uncovered in this study lead to the conclusion that the relationship between health factors and efficient seeing should be studied. In the larger sense, seeing is a psychophysiologic process. Strictly anatomic concepts of seeing appear to circumscribe thinking and practice.

CHANGES IN THE CILIARY BODY AFTER CONTUSIO BULBI IN WHICH ONLY THE ANTERIOR SEGMENT OF THE EYE IS AFFECTED*

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Contusion blows to the anterior segment of the eye cause direct and indirect changes in the structure and function of the ciliary body. The damage is dependent upon the type of blow that causes the injury. A slow, pressure blow is fairly well tolerated but may cause hemorrhages into the anterior chamber, dislocation of the ciliary body, and rupture of the globe; whereas a sudden blow may cause a tearing of the iris, dislocation of the lens, and rupture of the ciliary-muscle fibers. In the latter type of injury, tearing occurs before any adjustment of elastic tissues can take place.

Since the anterior segment of the eye can be studied by ordinary means of examination, changes that occur in the cornea, iris, and lens after contusion have been well described. The ciliary body cannot be seen, consequently little is known about the changes that take place after blows to the tissue. The pathologic picture shown in this report was induced in monkeys (Macaca mulatta). A pellet weighing 381 mg. was shot from an air pistol that was held 4 cm. from the surface of the globe at an angle of 20 degrees to the tangential plane. A slow, pressure blow was applied to the corneoscleral region by striking the eye with a plunger propelled by a strong spring. The following report is generalized and is necessarily brief.

One case of contusio bulbi in man is reported to illustrate the practical value of this study.

IMMEDIATE CHANGES AFTER CONTUSION

Immediately after a contusion of the eye, provided that the blow is not too severe, there is a contraction of the pupil. This is followed in a few seconds by dilatation of the pupil, widening of the palpebral opening, and a pseudoproptosis that quickly disappears. The pupil is usually irregular and is seldom fully dilated. A miosis may be caused later by tonic spasm of the sphincter muscle. Hemorrhage and transudates into the iris may accentuate the contraction.

The anterior chamber may be of irregular depth following contusio bulbi. The irregularity would suggest a dislocated lens; however, the irregular contraction of the iris and a subnormal intraocular pressure may cause the abnormality.

There is usually a temporary fall of the intraocular pressure after blows to the globe. In most instances, the tension returns to normal after 20 or 30 minutes. Hemorrhage into the anterior chamber may be severe and may cause a rise of the pressure to above normal levels. Rupture of the globe is indicated if the tension remains below normal for several days.

Blood is seen in the anterior chamber of practically every case of contusio bulbi. The amount varies from a few flecks to a complete filling of the chamber. When one of the large radiating vessels is torn through, near the iris base, severe hemorrhage occurs. A part of the bleeding may come from the ciliary body. The hemorrhage usually comes from vessels adjacent to the injury but may be on the opposite side of the anterior chamber. Blood in the

* Read at the twenty-ninth annual meeting of the Pacific Coast Oto-Ophthalmological Society, at Los Angeles, May 28, 1941.

anterior chamber may prevent a view of the fundus. Slight hemorrhages settle to the lower half of the chamber after a few hours, leaving the upper half of the pupil clear. Severe bleeding may not clear for days, if at all.

The iris is torn in many cases of contusion. All parts are subject to injury. The sphincter portion may show ruptures as shallow indentations or as tears extending to the iris base. Multiple tears or rents may be linear, spiral, circular, or radiating. Large tears are frequently seen at the base of the iris. Such tears are produced by sudden, sharp blows to the region of the corneoscleral limbus and not by stretching of the limbic ring and a flattening of the anterior chamber. Transillumination is a valuable means of determining the presence of an iridodialysis.

The lens is subject to change through dislocation and altered refraction. There is a high incidence of luxation after contusing blows. The lens may become almost spherical after rupture of the zonular fibers. These fibers are torn in all cases of iridodialysis caused by nonpenetrating blows to the eye. Scar tissue in and around the iridodialysis opening helps to hold the lens in place. Exudate and hemorrhage in the anterior chamber may organize to leave a thin layer of scar over the iris and pupillary space, covering the anterior lens surface. Glaucoma frequently follows subluxation and luxation of the lens. This may be due either to a forward pressing of the iris tissue with closure of the iris angle or to chemical irritation from the disintegrating lens substance.

Hemorrhages, edema, and exudates are found in the ciliary body after blows at or

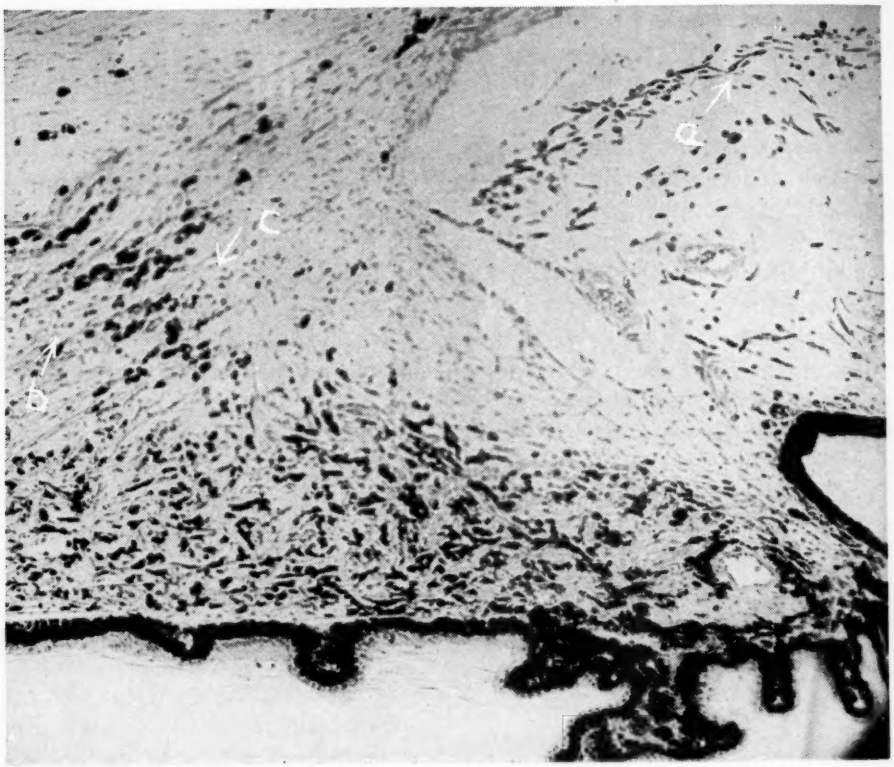

Fig. 1 (Kilgore). a, marked edema of the iris base; b, round-cell infiltration and pigment migration; c, an area where the normal tissue is replaced by scar formation.

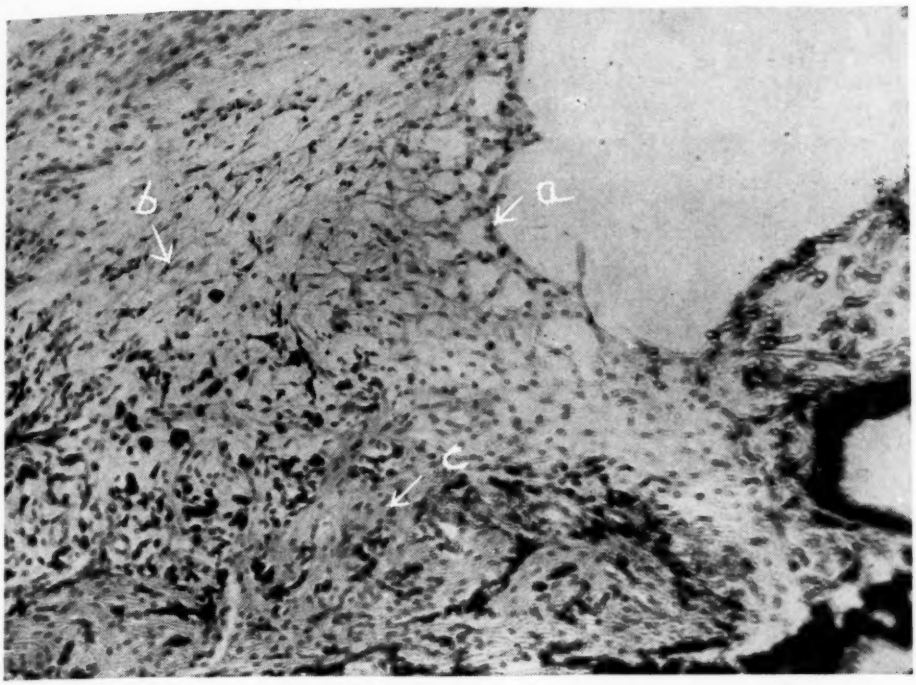

Fig. 2 (Kilgore). A later state of changes in the ciliary body. a, cystic degeneration; b, pigment degeneration and scar formation; c, a portion of the ciliary body that has a few bundles of normal muscle tissue.

near the corneoscleral limbus. The muscle fibers may be torn and the normal attachments to the sclera may be broken. Extensive hemorrhage may come from torn ciliary vessels. The retina may become detached at the ora serrata.

Later changes after contusion

After several days a new picture is seen in and around the ciliary body as is illustrated in figure 1. Hemorrhage is no longer present, but there is an edema, a round-cell infiltration, a pigment migration, and some evidence of replacement of the ciliary body with scar tissue. The sclera is infiltrated with round cells. Figure 2 and figure 3 show a more extensive involvement of the ciliary body and iris. The adjacent cornea shows no changes. Figure 4 shows the atrophy that is commonly found in these cases after the lapse of several weeks. The ciliary body and its processes have atrophied. The pigment cells have disappeared and the lesion has healed.

Symptoms after contusio bulbi

In man: After blows to the ciliary region, the eye is painful and there is usually a marked photophobia and lacrimation. Attempts to read precipitate added pain and discomfort in the eye. Atropine will usually relieve the painful ciliary and sphincter spasms. Tenderness of the ciliary region improves after a time, and the redness and discomfort disappear. In many instances, the power of accommodation is markedly subnormal. Attempts at reading and doing close work precipitate pain in the eye and headache. Cramps of the ciliary muscle occur. The eye tires easily and the patient complains of difficulty in doing his ordinary work. A case is reported to illustrate the symptom syndrome after contusio bulbi.

On September 7, 1937, a man, aged 28

years, suffered an injury to the front of the globe of the left eye, caused by a piece of glass from an exploding bottle.

There was a cut in the conjunctiva that began at a point 2 cm. temporally from the limbus and crossed it at the 3-o'clock position. The globe was not penetrated except for a cut in the cornea in from the limbus at the 3-o'clock position. There were no intraocular complications except a small hemorrhage in the anterior chamber at the point of injury.

Progress: On September 27, 1937, the eye had healed except for a small red spot at the site of injury. On November 9, 1937, the patient was complaining of poor vision with the affected eye. Headache and pain developed after reading and use of the eyes. The refraction was: R.E. −0.50D. cyl. ax. 105°; L.E. −0.25D. sph. ⊂⊃ −1.50D. cyl. ax. 105°. The vision was 6/7 with the right eye and 6/12 with the left eye.

On May 10, 1940, the patient complained of fatigue and tiring of the eyes with headaches after use of the eyes. The vision of the right eye was 6/7 with a correction of a +1.25D. sph. ⊂⊃ +1.00D. cyl. ax. 110°. The vision of the left eye was 6/10 with a +0.75D. sph. ⊂⊃ +2.00D. cyl. ax. 105°. The near vision was 14/14 with the right eye and 14/21 with the left eye.

On February 10, 1941, the patient's complaints were but little different from those formerly recorded. The eye tired quickly and headache developed after usual work. There was no residual intraocular pathologic condition. A linear scar could be seen in the conjunctiva and cornea at the site of the injury.

Treatment: The pupil should be dilated early and kept atropinized until the redness and tenderness have disappeared. General measures, consistent with the situation, should be directed to prevent complications. After the eye has fairly well recovered, the full correction of the refraction of the injured eye should be worn constantly to give as much comfort as possible. Malingerers may be encountered with a history of injury to the anterior ocular segment. The finding of subnormal accommodation in one eye, and

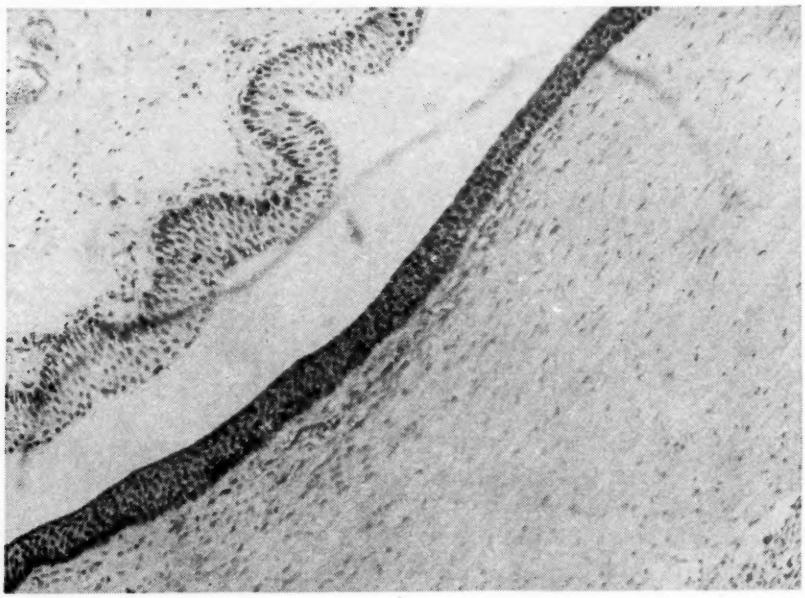

Fig. 3 (Kilgore). The cornea adjacent to the ciliary body shown in figure 2. No changes are seen in the cornea.

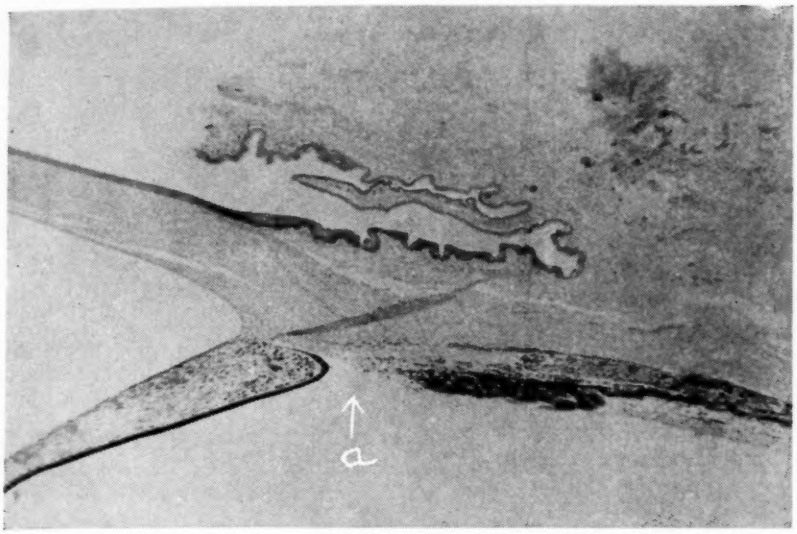

Fig. 4 (Kilgore). Shows the extreme atrophy that results from contusion in the region of the ciliary body. a, an area of scar formation. Posterior to this area, the pigment is abnormally heavy. The ciliary body has disappeared, with the exception of this pigment.

a history of aggravation of the discomfort after ordinary use is characteristic of such cases and should help to substantiate the diagnosis.

Prognosis: The prognosis of these cases is uncertain. Secondary changes affecting the iris, lens, and anterior chamber may cause either glaucoma or result in an eye that is not serviceable. Subnormal accommodation is to be expected and with it early eye fatigue, ocular discomfort, blurred vision, and headache. Guarded encouragement can be given most of these patients, with assurance that the condition will improve. Months are usually necessary for the expected recovery.

Iris and lens changes affect the function of the ciliary body through adhesions binding the iris and lens together. All iris and lens movements are hindered, interfering with vision. Glaucoma may develop secondary to the binding of the iris to the posterior surface of the cornea. Iris bombé may result from binding the pupillary border to the lens.

Summary

1. Sections of eyes that have suffered experimental contusio bulbi have been presented to show the pathology found in the ciliary body after contusions.

2. Symptoms following even minor blows to the front of the eye can be explained by the cyclitic changes.

3. Atrophy of the ciliary body may explain some of the prolonged visual disturbances.

4. The prognosis should be guarded in cases of contusion. Insignificant blows may be followed by a permanent visual disability.

5. A case report is submitted to illustrate the practical correlation of pathologic and clinical observations.

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ACUTE FOLLICULAR CONJUNCTIVITIS RESEMBLING BÉAL'S TYPE

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During July, August, and September of 1941 sporadic cases of acute follicular conjunctivitis appeared among San Diegans. In the latter part of October and the first half of November a small epidemic of this disease appeared among the workers of the Consolidated Aircraft Corporation. Simultaneously the malady was reported in Portland, and in December, 1941, and January, 1942, an epidemic appeared in San Francisco. The exact number of cases among the workers at Consolidated Aircraft Corporation was not known, but 66 were observed and treated by me. The cardinal characteristics of the disease were (1) acute or subacute unilateral onset with profuse lacrimation, (2) absence of exudate, (3) severe hyperemia of the conjunctiva, (4) folliculosis which was most marked in the conjunctiva of the inferior fornix, (5) slightly tender preauricular adenitis, (6) swelling of the lids, (7) complete resolution in 7 to 21 days, (8) absence of inclusion bodies or pathogenic bacteria in scrapings from the conjunctiva, and (9) abundance of lymphocytes in the conjunctival scrapings.

The one complication in these cases not previously described in follicular conjunctivitis (Béal[1]) was superficial keratitis. It developed in 7 of the 66 cases, appearing three to six days after the onset of the conjunctivitis. The corneal involvement was accompanied by photophobia and the sensation as of a foreign body. Slitlamp examination revealed multiple tiny discrete superficial corneal infiltrations that stained with fluorescein. These tiny gray corneal opacities were in the deep layers of the epithelium and diffusely scattered over the corneal surface. After three or four days these lesions no longer stained and in 6 of the 7 cases they disappeared in one to three months, but the opacities in the seventh case were present and unchanged five months after their appearance.

Unless instituted soon after the onset of the disease treatment did not influence the course of the inflammation. When the second eye became involved while the first was under treatment, painting the conjunctiva with 1-percent silver nitrate usually aborted the infection. Solutions of phenyl mercuric nitrate 1:10,000 and 5-percent sodium sulfathiazole sesquihydrate were used as drops, but had no effect. One patient was given sulfanilamide (0.33 gr. per pound for five days) but it did not alter the course of the disease. Patients with the most severe cases were given small doses of typhoid-H antigen intravenously, and subjective improvement followed.

The following description is typical of these cases: A white man, aged 30 years, was seen on November 2, 1941, because of an inflamed right eye. Three days previously the eye had become inflamed, commenced to tear, and felt somewhat swollen and sticky. During the next two days the swelling, redness, and lacrimation increased, but there was no pain. Because of a slight foreign-body sensation he consulted the first-aid department of the aircraft factory, but no foreign body was found. Several of the men in this man's department had similar ocular inflammations. He thought that his trouble was due to duralumin dust, but admits that he may have rubbed his eye after handling tools contaminated by his fellow workers.

Ocular examination revealed 20/20 vision of each eye. There was slight

pseudoptosis of the right upper lid. The inferior palpebral conjunctiva was fiery red, and in the lower fornix there were many large follicles. The conjunctiva of the upper lid and fornix was similarly but less intensively involved; the bulbar conjunctiva was injected and slightly edematous. The cornea was clear. The most striking characteristic of the conjunctivitis was its follicular nature and its predilection for the conjunctiva of the fornices, particularly the lower. The only ocular discharge was lacrimation, and tears dripped continuously. The preauricular lymph node was enlarged and slightly tender.

Laboratory examination. After 48 hours' incubation at 37°C. the only growth present on a blood-agar plate inoculated from the conjunctiva was two colonies of nonhemolytic Staphylococcus albus. Microscopic examination of conjunctival scrapings stained with Giemsa's and Gram's stains revealed no bacteria or inclusion bodies, but an abundance of lymphocytes was present.

Progress. On the patient's first visit the palpebral conjunctiva was treated with 1-percent silver nitrate. Eye drops of a solution of phenyl mercuric nitrate 1:10,000 and hot packs were prescribed, but on the next day no change was apparent. On the sixth day after the onset of the conjunctivitis the patient complained of blurred vision and foreign-body sensation in the right eye and tearing of the left. Ten or 15 superficial punctate staining areas were observed in the pupillary area of the cornea of the right eye. The left eye had an incipient conjunctivitis, which was treated with 1-percent silver nitrate, phenyl mercuric nitrate, and hot packs. On the seventh day the cornea of the right eye no longer stained, the conjunctivitis was slightly improved, and the conjunctiva of the left eye was almost normal. Fifteen days after the onset the conjunctivitis of the right eye had completely subsided and six weeks later the corneal infiltrates had disappeared.

Comments

As pointed out by Duke-Elder,[2] follicular conjunctivitis is a catch-all diagnosis for a hodge-podge of diseases with a striking but perhaps unessential common characteristic. Nevertheless there are diseases in this group which are clear-cut entities. The follicular conjunctivitis herein described appears to correspond closely to the acute follicular conjunctivitis described by Béal. The keratitis that appeared in only 7 of 66 cases may well be only the manifestation of increased virulence. When reports of this conjunctivitis, which was apparently rampant on the West coast, are all in, it will probably be found that the percentage of cases with corneal involvement was small.

It is interesting that cases of pneumonitis which were thought to be caused by a virus appeared simultaneously and in the same localities as this conjunctivitis which was probably also due to a virus.

501 Medico-Dental Building

References

[1] Béal, R. Sur une forme particulière de conjonctivite aiguë avec follicules. Ann. d'Ocul., 1907, v. 87, p. 1.

[2] Duke-Elder, Sir W. S. Text book of ophthalmology. St. Louis, C. V. Mosby Company, 1938, v. 2, p. 1581.

NOTES, CASES, INSTRUMENTS

A CASE OF ARACHNODACTYLY WITH DISLOCATED LENSES

SYDNEY S. DEUTCH
Pittsfield, Massachusetts

The congenital disease known as arachnodactyly, or Marfan's disease, seems to be rare enough to warrant this case report. This syndrome is a congenital and hereditary maldevelopment of the bony structures, muscles, and visceral organs. In over 50 percent of the cases reported ocular defects have been noted. While the disease itself is but little influenced by treatment, the abnormal developments in the eye, if left untreated, can result in marked loss of visual acuity or blindness. The signs at birth are so indefinite that the diagnosis is not suspected until the child starts going to school. Unfortunately, so much damage may have been done to the eyes by this time that the visual acuity may be lowered permanently. If the attending physician is familiar with this syndrome, he is likely to make the diagnosis early, and, in this way, useful vision may be maintained through life. The youngest child having Marfan's disease, with dislocated lenses, whose case I could find reported in the literature was 26 months old.

Fig. 1 (Deutch). Case of arachnodactylia with ectopia lentis. Note the unusually long arms and legs, the claw-shaped position of the index fingers and thumbs, the lack of subcutaneous tissue, especially on the chest.

The patient, S. T., aged 14 years, was referred by an optometrist. He complained of loss of vision in the right eye with failing vision in the left. The eyes had not been painful. Two years before the examination, the right eye became red and remained so. The left eye had not been inflamed. The examination revealed many characteristics of Marfan's disease. The patient was unusually tall for his age; his arms were long and thin, the fingers tapering and elongated. The thumb and index finger assumed a claw-shaped appearance. There was little subcutaneous fat anywhere on the body. The ribs protruded prominently, especially at the costosternal junction. His feet were large; he required size 10½ shoes. The growth of his feet had been so rapid that he outgrew his shoes before they were

worn out. There was no evidence of lordosis (fig. 1).

The examination of the right eye revealed a shrunken globe that was deviated nasally for about 45 degrees. The conjunctiva was injected, the cornea opaque. The anterior chamber was shallow and contained an opaque dislocated lens. The iris had become so atrophic that by indirect light from the slitlamp a fundus reflex was visible. Ophthalmoscopic examination could not be made. The ocular tension was soft, the vision nil. The patient's appearance was markedly improved when a stock artificial eye was fitted over the shrunken eyeball. It is worn all day without discomfort (fig. 2).

Fig. 2 (Deutch). The right eye: A, on admittance. Note the shrunken globe deviated nasally for about 45 degrees; B, the improved appearance after a stock artificial eye had been fitted over the shrunken eyeball.

In the left eye vision sufficed for counting fingers at three feet. This was corrected to 20/200 with a −18.00D. sph. The corneal diameter was larger than usual. The anterior chamber was clear and deep. The iris was tremulous, and the portion near the limbus from the 12- to the 2-o'clock position was atrophic. The pupil was small and reacted sluggishly to light. The fundus details could not be seen. The lens was not in its normal position, but could not be seen in the vitreous. Tension was 40 mm. Hg (Schiötz). The field of vision showed a constriction in the upper nasal quadrant.

The patient's left eye was treated with a 2-percent solution of pilocarpine instilled every three hours. This did not reduce the ocular pressure. An iridencleisis operation was performed. Part of the iris was pulled into the paracentesis wound so the opening would remain partially patent and form a fistula. This controlled the abnormal intraocular pressure for a period of three months. Then drainage ceased. The same type of operation was performed again. The pressure was 19 mm. after the second operation. Because the vision was poor and the prognosis bad, arrangements were made to transfer the patient to the Perkins Institute for the Blind. While he was there, the pressure rose again. A new attempt was made to construct a filtrating scar. During his stay in the hospital, the lens spontaneously prolapsed into the anterior chamber. This necessitated another operation, this time for removal of the lens. It was found to have more than twice the focal strength of an ordinary lens. The following method was used to determine the strength of the lens: A small source of illumination was held in front of the lens and the distance measured from the opposite side of the lens to the point of focus. After the patient's discharge from the hospital, his refraction was tested. Vision was 20/60 and he read J1 with the following correction: +7.75D. sph. ⌯

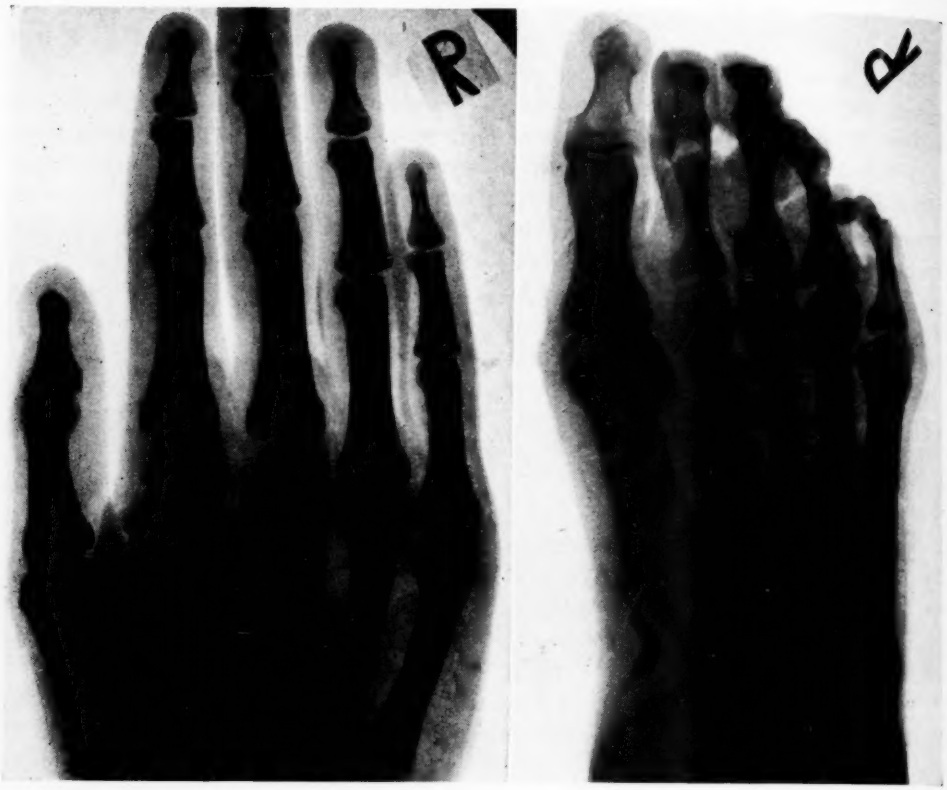

Fig. 3 (Deutch). X-ray studies of right hand and right foot showing elongation of the metacarpals and phalanges with incomplete fusion of the epiphyses.

+1.50D. cyl. ax. 130°. Add +2.25D. sph. At this time there was a good filtrating bleb at the 12-o'clock position. Now the fundus could be seen clearly. The nerve head was neither cupped nor pale and was well outlined. The retina was free from hemorrhage and exudate. The vessels appeared to be tortuous. The ocular pressure was 19 mm. (Schiötz). The visual fields showed no increased loss. The condition of the left eye remains the same after two years of follow-up observance.

The X-ray studies by Dr. M. J. Cox showed marked elongation of the metacarpals and phalanges, with incomplete fusion of the epiphyses, indicating delay in fusion of the epiphyseal lines (fig. 3). The examination of both feet also showed an elongation, particularly of the metatarsals, with incomplete fusion of the epiphyses.*

74 North Street.

ALLERGIC CONJUNCTIVITIS AND DERMATITIS FROM THE TOPICAL USE OF SODIUM SULFATHIAZOLE AND SULFATHIAZOLE

W. Howard Morrison, M.D.
Omaha, Nebraska

The topical application of one of the sulfonamides, particularly sulfathiazole

* A complete review of the subject has been published in the March, 1942, issue of the Archives of Ophthalmology by Dr. Andrew Rados.

or sodium sulfathiazole in ointment form is in widespread use. Not only does the ophthalmologist frequently prescribe these drugs, but the general practitioner also uses them in the treatment of many external ocular inflammations.

Toxic reactions from the parenteral and oral administration of the sulfonamides have been well investigated and reported. Recently I have had patients complain of smarting and irritation and other unpleasant reactions after the application of sodium sulfathiazole or sulfathiazole in ointment form. The following is a report of a particularly severe reaction from the use of 5-percent sodium sulfathiazole and of 5-percent sulfathiazole in a lanolin-petrolatum base.

A nun, aged 63 years, came for consultation on November 15, 1941, complaining of burning and scratching of the eyes of some three months' duration. Ocular examination disclosed a scanty mucoid discharge with some agglutination and crusting of the lid margins. There was present a moderate thickening and redness of the palpebral conjunctivas, particularly of the lower folds. A diagnosis of chronic catarrhal conjunctivitis was made. Sodium sulfathiazole ointment, 5 percent in a lanolin-petrolatum base, was prescribed to be applied to the lid margins and inside the eyelids three times a day. The use of hot compresses was also advised. Three weeks later the patient telephoned to say that she was experiencing increased irritation of the eyes, particularly itching and swelling of the lids. She was asked to come to the office immediately. Examination at this time revealed markedly red boggy lids. The skin about the eyes was so edematous that the patient could hardly see.

The conjunctivas of the lids were pale pink in color, swollen, and covered in places by a milklike film. A diagnosis of allergic conjunctivo-blepharitis was made. The use of the sulfathiazole was discontinued and the patient advised to apply cold compresses and zinc-oxide ointment to the skin of the lids.

Two days later the skin appeared less red and edematous and in three more days the skin and conjunctivas appeared normal except for a slight thickening of the palpebral conjunctival surfaces.

The use of the lanolin-petrolatum base without the sulfonamide was then prescribed for the right eye three times a day and the base plus 5-percent sulfathiazole for the left eye three times a day. After four days there was no reaction of the right eye or lids, but the left eye, into which the sulfathiazole had been instilled, showed typical redness and edema of the lids and chemosis of the conjunctivas.

This then proved that the sodium sulfathiazole and sulfathiazole were the active sensitizing agents. The lanolin-petrolatum base proved to be innocuous.

This case report indicates that certain individuals develop a sensitivity to the topical use of sulfathiazole or its sodium salt. A certain amount of care and observation should therefore accompany the use of the drugs.

Medical Arts Building.

INTRAOCULAR FOREIGN BODY OF WOOD*

SIDNEY A. FOX, M.D.
New York

Of all intraocular foreign bodies those consisting of wood are the least common. Being of relatively light material, a flying wooden particle must attain a high rate of speed in order to penetrate the tough coats of the eye. Its direct accidental introduction into the eye, as occurs with

*Preliminary report presented before the New York Society for Clinical Ophthalmology on February 3, 1941.

cilia and wisps of cotton, is also rare. Even more uncommon, apparently, is the retention of normal vision by an eye in which a wooden foreign body has lodged. Among the few cases reported I have been unable to find a single one in which there was not an appreciable loss of vision or of the eye itself. Hence the following case history:

On December 9, 1937, a nine year old white girl, while watching her father splitting wood, stooped down to pick something up. She suddenly felt a sharp pain in her right eye but this soon passed away and she paid no further attention to it. The following morning she complained of blurred vision in the eye and help was sought.

On examination the vision was 20/100+1 in the right eye and 20/20 in the left. Both eyes showed normal lids. The right bulb was somewhat reddened as compared with the fellow eye but there was no real ciliary injection, no photophobia, no lacrimation, and no blepharospasm. The cornea of the right eye showed a 4-mm. linear horizontal laceration at the 4-o'clock position, about 2 mm. in from the limbus. The pupil was irregular and in semidilatation. The pupillary border from the 4- to the 6-o'clock position was absent. The ocular tension was normal.

Slitlamp examination of the right eye disclosed a through-and-through corneal laceration which shelved from above downward and backward. Between the lips of the corneal wound posteriorly could be seen several tiny wooden splinters and a large clump of dark iris pigment. The aqueous showed a mild flare, a few cells, and some pigment granules. The iris ruff was absent from 4 to 6 o'clock on the iris dial. At 3 o'clock, just nasal to the lesser circle border, a thin wooden splinter estimated to be about 1 mm. wide and 2.5 mm. long could be seen partially imbedded in the iris stroma. The lens and vitreous were clear and the fundus was negative.

Examination of the left eye disclosed no abnormalities.

The slitlamp picture of the right eye was reconstructed as follows: As the child stooped down a splinter of wood penetrated the cornea upward leaving a trail of wooden splinters in the lips of the wound, the main piece lodging in the iris. It was this stooping position which accounted for the anterior lip of the corneal wound being higher than the posterior opening into the eye. With rupture of the cornea there was a gush of aqueous outward, carrying the iris with it, the iris border being caught in the wound. The iris then retracted, either immediately, due to its inherent elasticity, or during the night, as the anterior chamber refilled and the pressure of the aqueous between the cornea and the iris forced it back into normal position. Part of the pupillary border was left behind, being caught tightly in the corneal wound.

It was not easy to decide what procedure to adopt. The obvious course was to enter the anterior chamber and attempt removal of the foreign body, by iridectomy if necessary. However, there were still the intracorneal splinters, which could not be removed without irreparable damage to the cornea. Since the eye was quiet and painless it was decided to "be conservative." (Another way of saying "to temporize," I'm afraid.) The patient was kept under strict surveillance and the usual atropine, hot compresses, and dark glasses were prescribed. Within 10 days the eye was completely white, and the flare had disappeared. The vision was 20/20 in both eyes. The pupil remained slightly dilated and irregular and the whole width of the iris from 4 to 6 o'clock gradually became gray and atrophic. The wooden splinter in the iris slowly became

encapsulated and the surrounding area pigmented. Over the course of the years the pigment in the corneal wound has been gradually absorbed and the wooden particles, though still present, have shrunken considerably.

On February 2, 1942, over four years after the accident, the vision was still 20/20, and there was little to see externally except for a faint linear corneal nebula, a slight pupillary irregularity, and absence of the ruff as described above. The now young lady is red haired with gray irides, and the slightly lighter atrophic patch of the iris is scarcely noticeable. The foreign body in the iris is completely covered by connective tissue and surrounding dark pigment.

This case presents several noteworthy features aside from the rarity of the retention of normal vision in the presence of a long-retained intraocular wooden foreign body. First, it is of interest to see how much damage a young eye can sustain and still remain functionally and even cosmetically normal. This is a case of ruptured globe with iris incarceration and retained intraocular foreign bodies. Yet the vision is normal and there is even no pigmentation of the cornea at the site of injury, as there probably would be in an older eye.

Also, this case furnished a front-row view of what happens to a foreign body in the interior of an eye over a long period of time. It was easy and fascinating to follow biomicroscopically the gradual encapsulation and surrounding pigmentation of the iris splinter and the gradual dissolution of the pigment in the cornea.

Finally, this case presents a question of procedure. Conservative treatment here has preserved an eye normal in function and appearance. On the other hand all ophthalmologists are familiar with reports of delayed intraocular flare-up in such cases, often occurring many years later. Faced with a similar situation again, I am not sure that I would allow the foreign body to remain in the eye, especially if there were no corneal foreign bodies to complicate the picture as in this case. Inability to keep the patient under constant surveillance would also call for more drastic action. It must be admitted that good fortune as much as good judgment has been responsible for the favorable outcome in this case—so far.

110 East Fifty-third Street.

AN IMPROVED PUPILLOMETER

OLIVER P. BOURBON, M.D.
Los Angeles

The pupillometer shown in the accompanying illustration was designed for use in making routine examinations of the eyes and with two objects in view: to save time and to obtain accuracy.

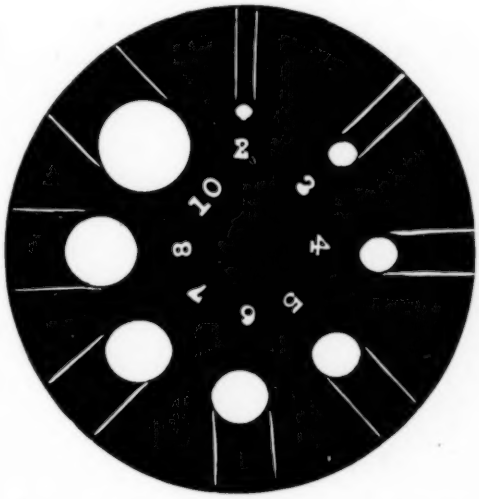

Fig. 1 (Bourbon). An improved pupillometer.

It consists of a circular black metal disc, 5 cm. in diameter. Around the circumference and a few millimeters inside its outer border, there is a series of round apertures, ranging in diameter from 2

mm. to 10 mm., corresponding to the different sizes of pupils. The diameter of each aperture is marked in millimeters, and white lines extend from each side of the aperture to the edge of the disc. The distance between any two white lines is therefore equal to the diameter of the aperture enclosed by them.

By using the white lines an actual measurement of the diameter of the pupil may be made, or the size of the pupil may be estimated by a comparison of the pupil with a similar-sized aperture.

The size and shape of the disc make it possible to place it alongside the nose close to the eye being examined. It is then turned until a position is obtained in which the two white lines point to either side of the pupil. This position is easily located, for the edge of the disc is close to the pupil and there are no other lines nor marks to cause confusion. The millimeter reading of the enclosed aperture gives the diameter of the pupil.

If the patient is nervous or intractable, the disc can be held as close to the eye as the patient will permit, and a comparison of the size of the pupil with the different apertures in the disc enables the examiner to estimate approximately the diameter of the pupil.

The instrument can also be used to estimate the reaction of the pupil to light. The size of the pupil is first measured under ordinary illumination. Then a smaller aperture is placed in position, a bright light is flashed on the eye and the size of the pupil is again estimated. The results of these two examinations will give the light contraction of the pupil in millimeters.

A similar pupillometer was described in 1910 in the textbook entitled "Diseases of the eye" by Dr. John E. Weeks. The one here presented differs materially from it, embodying several features not incorporated in the older design.

The instrument was made for me by the E. B. Meyrowitz Company of New York.

520 West Seventh Street.

SOCIETY PROCEEDINGS

EDITED BY DR. RALPH H. MILLER

BUFFALO OPHTHALMOLOGIC CLUB

February 13, 1941

DR. JAMES G. FOWLER, *presiding*

FACTS ABOUT RETINAL DETACHMENT

DR. IVAN J. KOENIG said that prior to 1930, 20 percent of all the adult blind lost their vision through retinal detachment. Sir William Lister, in 1927, expressed a universal opinion when he stated that "to operate on a case of retinal detachment is practically valueless."

The first retinal tear was noted by Coccius in 1853 and a little later one was reported by Von Graefe. DeWecker in 1870 thought the tear was the cause of the detachment. Operative procedure of the cautery type was first attempted by Martin, DeWecker, and de Luca in 1881. Deutchmann in 1896, used ignipuncture at the site of the retinal tear. After this Gonin carried on and correlated the facts presented by others into a principle. Gonin maintained that the hole or retinal tear was the cause of the detachment and laid down these principles based on anatomic facts:

1. One or more retinal tears are present in almost all cases of idiopathic detachment.

2. Tears are caused by dragging of the vitreous at the site of a previous vitreous-retinal adhesion (described by Vogt).

3. The hole allows the fluid of the vitreous to enter behind the retina, separating it from its pigment layer (Leber's theory). Von Graefe, Sourdille, and others have brought about retinal detachment experimentally by inflammatory reaction. However, an exudative process would seem to be the cause only where elements are present to produce it, such as toxemia of pregnancy.

From the time of his first paper on cure of retinal detachment by thermocautery, Gonin continued working and experimenting until the publication of his results in 1929, and from that time his work has been recognized.

Weve of Amsterdam modified Gonin's operation, using microcoagulation through the sclera and choroid with a current as low as 50 milliamperes. He placed multiple punctures around the hole, thus sealing it off. Safar, of Vienna, and Walker, of this country, popularized the micropin method.

The chemical cautery method of the Guist and Lindner modification should be mentioned, also the pyrometric electrode of Coppez with diathermy, as well as the flat coagulation of the sclera by Larssen. The thermophore method of Langdon should also be mentioned, and the use of electrolysis as employed by Vogt, von Szily, and Machemer is a method worth considering.

Anatomically it is known that detachment develops between the outermost limits of the layer of rods and cones and the epithelial layer of the retina; for example, in the layer of pigment epithelium. The hole or tear involves the retina down to the pigment epithelium. The hole or tear assumes various shapes and forms; 10 percent of these are really disinsertions of the retina or a tearing away from the ora serrata and probably a result of cystic degeneration at this point. Tears are seen more easily in recent cases with clear vitreous.

The types of electrodes are many. All endeavor to create an inflammatory reaction of the choroid to bring about an adhesive choroiditis with the final result of an adhesion between the retina and choroid.

Dr. Koenig uses the diathermy micropin-coagulation method. During the past four years he has used a single electrode with a micropin at its end. It is easier to manipulate and the depth of the puncture can be regulated. He attempts to penetrate no deeper than the choroid. Using this method it is usually possible to finish without inducing marked hypotony. He coagulates the entire area of detachment, paying particular attention to the area of tears or disinsertions.

The final results of surgical reattachment give a universal record of about 50 percent cures. Most of the unsuccessful results are found in cases of long standing. It would seem the longer the surgery is delayed, the greater the detachment and the less chance of restoring visual acuity. These facts emphasize the necessity for early surgery.

Dr. Koenig reported a group of eyes operated on as follows: The total number of eyes was 20. In 14 of this number the retina was reattached, in 6 the result was failure. Tears were found in 12 of the eyes, disinsertions in 3, and no tears could be discovered in 5. Vision obtained was: 6/45 to 6/30, 3 eyes; 6/20 to 6/15, 2 eyes; 6/12, 5 eyes; 6/9, 2 eyes, and 6/6, 1 eye.

A moving picture in color of Dr. Koenig's detachment operation was shown.

Discussion. Dr. Joseph Schutz said the mechanism of detachment of the retina is thought to be through distension, depression, retraction, or exudation. The chief factors in etiology are myopia, trauma, chorioretinitis, senile degeneration of the retina, and cystoid degeneration of the retina at the ora. About 67 percent of detachments occur in males and 33 percent in females. Retinal detachments are more common in older people although in younger people high myopia or trauma may be the cause. It is necessary to differentiate between serous and flat detachment. If hypotony is present the prognosis is bad. Possible complications of surgery are iridocyclitis, cataract, and secondary glaucoma.

Sheldon B. Freeman,
Secretary.

SAINT LOUIS OPHTHALMIC SOCIETY

March 28, 1941

DR. WILLIAM M. JAMES, *presiding*

CONTACT LENSES

DR. EDMUND ALVIS gave a statistical review that included all the patients fitted with contact lenses in Saint Louis previous to March, 1941.

Total number of patients, 47: male, 11; female, 36.

Divided according to the condition present, there were:

Condition	*Cases*	*Percent*
Myopia	34	72.3
Hyperopia	2	4.3
Keratoconus	6	12.7
Unknown	5	10.6

Considering each of these groups according to the length of time the lenses could be worn, it was found that:

Myopic patients wore their lenses:

Time	*Patients*	*Percent*
Over 8 hr.	9	26.5
Over 4 hr.	16	47.1
Less than 4 hr.	11	32.3
Unknown	7	20.6

Patients with keratoconus wore their lenses:

Time	*Patients*	*Percent*
Over 8 hr.	2	33.3
Over 4 hr.	4	66.6
Up to 3 hr.	1	16.6
Uncomfortable but wears them	1	16.6

Patients with hyperopia wore their lenses:

Time	*Patients*	
Over 8 hr.	1	(aphakia)
Over 4 hr.	1	(hyperopia of less than 2D.)

Considering the entire group from the standpoint of the type of lens worn, 24 patients were fitted with "stock" lenses, and 13 of these could wear their lenses over four hours; 19 were fitted with molded lenses, and of these 8 could wear their lenses over four hours. The type of lens worn by four patients is unknown. Of the group wearing "molded" lenses, 12 were fitted with lenses made in this country, and of these 8 could wear them more than four hours. Thus it was found that of the group wearing the "stock" lenses 54.2 percent could be called successfully fitted, and of those using the more modern "molded" type 66.6 percent were equally well satisfied.

In conclusion it can be said that the most important improvement in the fitting of molded contact lenses in Saint Louis has been the development of the ability to adjust these lenses after they have come from the manufacturer. The percentage of "successful" cases in the "stock" group should rise with improvement in molding technique because a much more careful selection of cases is then possible.

Discussion. Dr. John Green said he would like to ask whether any disasters had occurred in the cases surveyed by Dr. Alvis. In New York he saw one patient who developed a severe keratitis following prolonged wearing of a contact lens. The surgeon was disinclined to ascribe the keratitis to the irritation of the contact glass. Vision was lost.

Dr. William James said he had prescribed contact lenses for seven patients. Two of the seven felt that the lenses were worth while. One patient with keratoconus wears the contact glass over one eye as long as 13 hours. If a patient comes to his office requesting contact lenses and satisfactory vision is secured with ordinary lenses, he discourages the use of contact lenses.

Dr. H. R. Hildreth asked if Dr. Alvis in his series had run across, either in his own practice or in reports in the literature, any cases of quiet healed trachoma in which the vision was improved by the wearing of a contact lens.

Dr. E. Alvis in conclusion said that in this Saint Louis series there were no disasters from wearing contact lenses. Some physicians reporting on the subject believe contact lenses help keratoconus. Some described cases in which the progress of keratoconus stopped with the wearing of contact lenses. He had had only one case in which a presbyopic patient wore contact lenses, and he had no trouble wearing them or putting them in. Twenty-four patients were fitted with stock lenses, about 50 percent of them successfully. Of the last group, in which molded lenses were worn, 8 of the 12 were satisfied. The size of the trial set has been a source of argument with many ophthalmologists. Those who favor the stock lenses are in favor of larger trial sets. Dr. Alvis thinks the difficulty with the stock lens is not with the lens itself but that the lenses are fitted to people with aspherically shaped scleras. It is best to have the patient wear the lenses a while; then if he exhibits a blanched area the lens must be reground in this region.

Adolph C. Lange,
Editor.

NEW YORK SOCIETY FOR CLINICAL OPHTHALMOLOGY

March 3, 1941

DR. MORRIS DAVIDSON, *presiding*

PRACTICAL POINTS IN OFFICE TREATMENT

DR. JAMES W. SMITH spoke on this subject during the instructional hour.

THE USE OF INTRAVENOUS SODIUM IODIDE IN OPHTHALMOLOGY

DR. ERNST METZGER stated that for the past 17 years he had been using intravenous sodium iodide for the resorption of hemorrhagic and inflammatory vitreous opacities and in interstitial keratitis. He considered the combination of this therapy with tuberculin in cases of slow, progressive exudative uveitis to be especially effective. Contraindications to its use were thyroid affections, increased body temperature, and menstruation. Hypersensitivity to iodine in other forms was not considered a contraindication, nor did the simultaneous application of yellow oxide of mercury or calomel lead to unusual complications.

The solution is administered 10 c.c. at a time in 10-percent solution and should be injected very slowly. It can be repeated every other day for several months. Control groups in which interstitial keratitis was treated separately with mercury inunctions, salvarsan, and sodium iodide intravenously showed best results with the latter.

THE TREATMENT OF INCIPIENT CATARACT

DR. ARTHUR M. YUDKIN stated that in his experience 35 percent of patients over 60 years of age showed some form of lenticular disturbance. In a careful study of approximately 75 cases of incipient cataract it was found that lens opacities were not amenable to either local or general therapy. But intumescence of the lens, characterized by subcapsular vacuoles and lamellar fissures laden with fluid, seemed to vanish under a well-regulated treatment of the body and mind of the patient.

The essentials of the treatment were the ruling out of all general and local diseases, administration of a well-balanced diet, and sedation of the nervous patient. If there was a definite dietary dyscrasia the patient was given 10 to 25 mg. of thiamin chloride every other day and a daily mixture of vitamin-B complex for two weeks. The latter consisted of the following components: vitamin B_1, 1,000 international units; vitamin B_2, 500 Bourquin-Sherman units; nicotinic acid, 20 mg.; and filtrate factor, 250 Jukes-Lipovsky units. This initial therapy was followed by the daily ingestion of the juice of at least two lemons and other fruit juices and a tablespoonful of potent brewer's yeast or its equivalent extract as a minimum dose. Vitamin-B complex should be given to the limit of the patient's tolerance.

Intumescence of the lens was removed in 60 percent of the cases if the patient carried out the therapeutic advice. There was no effect on opacities.

Discussion. Dr. Sigmund A. Agatston stated that wedge-shaped opacities in incipient cataract are water-clefts due to protein lens changes and asked how Dr. Yudkin distinguished between such changes and intumescence of the lens.

Dr. Joseph I. Pascal asked how Dr. Yudkin accounted for the improvement of vision in a swollen lens in which there was no opacification.

Dr. Bertram S. Kramer stated that years ago Dr. John E. Weeks used glycerine in a boric-acid solution locally for incipient cataract. He suggested that such therapy does good in some cases possibly because early lens pathology is fluid and

glycerine acts as a hygroscopic agent to draw off the fluid.

Dr. Yudkin stated that no improvement could be expected where there were protein changes in the lens. The exact explanation for refractive changes in the lens without opacification was not known. In diabetes, for instance, there is a change from hypermetropia to myopia. According to Duke-Elder this may be due to invasion of the lens by some substance or fluid. Local medication for lens changes were valueless in his experience. There is no harm in trying local treatment, but it is well to give a well-balanced diet also.

General anesthesia in ophthalmology

Dr. Milton C. Peterson stressed the importance of preoperative preparation of the patient. He urged early admission to the hospital to prevent mistakes at home and to assure proper preoperative medication. He said that preoperative atropine should never be given in dosages less than 0.03 gr. of a grain, and that less than this had no effect. General anesthesia is necessary in operations on young children, and for adults in the case of enucleations, and on highly nervous patients who are uncooperative. For short operations vinethane, ethyl chloride, and nitrous oxide were said to be best in the order named. For the longer operations the ether-drop method is probably the safest and should not be too light, as this may cause vomiting.

Avertin anesthesia is also good. Evipal and pentothal sodium intravenously are effective but more dangerous. Morphine increases the value of the intravenous barbiturates but must be given at least an hour before the operation. The administration of these anesthetics is never an office procedure.

Discussion. Dr. Benjamin Esterman asked whether avertin was used as complete or basal anesthesia.

Dr. Herman J. Burman stated that in his experience picrotoxin was sometimes used with evipal anesthesia.

Dr. Peterson in closing stated that avertin was not regarded as safe except for basal anesthesia. Picrotoxin is a direct antagonist of evipal but metrazol is a better restorative drug. Picrotoxin works better when used with the barbiturates, though convulsions may follow its use.

Treatment of vernal catarrh with dry ice

Dr. Vito La Rocca stated that for the past six years he had been treating cases of vernal catarrh by cauterization with carbon-dioxide snow. Applications were made directly to the anesthetized vegetations of the conjunctiva with a pencil of dry ice or through the medium of a small pointed container in which pieces of dry ice bring the temperature of the metal to 80°C. below zero. The usual reaction was congestion of the conjunctiva and slight pain for 24 hours. The treatment was repeated weekly, and in some cases had to be used for as long as several years, but in others was completed in five months with disappearance of the vegetations. The symptoms generally abated after the first few applications.

He considered the generally recognized failure of treatment of this condition to be probably due to the fact that the pathologic process of vernal catarrh was not in the conjunctiva alone but deeper in the superficial layers of the tarsus. This probably explained why in some transplants vegetations reappear through the graft. In his opinion there seemed to be no better way of treating vernal catarrh than to destroy the vegetations with solid carbon dioxide. Though it is a rather long-drawn-out process it has the advantage of

being harmless and of giving lasting results.

DACRYOCYSTORHINOSTOMY—AN OFFICE PROCEDURE

DR. DAVID J. MORGENSTERN described a new method of obtaining a permanent drainage opening from the tear sac into the nose by electro-coagulation, which has been published in this Journal (August, 1942).

USE OF ETHER IN TREATMENT OF DENDRITIC KERATITIS

DR. BERNARD KRONENBERG reported a series of eight cases of dendritic keratitis treated with anesthetic ether. The procedure is to anesthetize the cornea and then rub the ether firmly into the lesion with a cotton applicator. This is followed by the instillation of atropine, an antiseptic ointment, and patching of the eye. This treatment has the advantage of being painless, and there is no reaction such as follows the use of iodine. In this series one patient required only one treatment, four patients were healed after two applications, two required three applications, and one had to be treated 10 times.

The explanation of the action of ether as a specific for the virus lesion is not definite. Ether applied in such small quantities and for so short a period of time cannot act as a germicide. The reduction of the temperature due to the rapid evaporation of the ether is also unacceptable as an explanation, since the virus is cold-resistant. A specific action of some sort—perhaps a chemical affinity—must be assumed.

Discussion. Dr. Abraham L. Kornzweig said that the result here may be due to the curetting of the epithelium with the applicator.

Dr. Kronenberg said that the same amount of epithelial curettage is obtained with iodine or phenol and yet the cure is attained much more quickly with ether. This cannot be the whole explanation.

Sidney A. Fox,
Secretary.

COLLEGE OF PHYSICIANS OF PHILADELPHIA

SECTION ON OPHTHALMOLOGY

March 20, 1941

DR. FRANCIS HEED ADLER, *chairman*

MELANOMA OF THE CONJUNCTIVA WITH ORBITAL INVOLVEMENT. CASE REPORT

DR. W. E. FRY reported that not infrequently nevi, either pigmented or unpigmented, are seen in the bulbar conjunctiva. These are most frequently seen near the limbus in the region exposed by the palpebral fissure. A certain number of these nevi, in persons over 30 years of age, increase in size either spontaneously or as the result of the irritation of trauma or inflammation, and take on the characteristics of a malignant tumor. The present case report is an instance of this occurrence.

M. S., a woman, aged 50 years, was first seen at the Eye Dispensary of the Hospital of the University of Pennsylvania, on April 26, 1939. At that time the vision in her right eye was 6/15 and in the left eye 6/15−1. From the time she was 15 years old she had had a dark spot on the sclera of the left eye to the nasal side of the cornea. No change nor difficulty with this was noted until December, 1938. At that time there was some bleeding from the left eye, and after irrigating her eyes with boric-acid solution, a piece of hard black tissue, about the size of the finger nail of the little finger dropped from beneath the upper lid. Following this the bleeding stopped. She had no pain. From this time the tumor continued to grow.

It was painless. A second hemorrhage from the same mass occurred several weeks before her admission to the Hospital.

An exenteration of the left orbit was done on May 8, 1939. At the time of the operation it was found that the tumor mass occupied most of the nasal portion of the orbit. Convalescence was uneventful.

The patient was readmitted to the Hospital on July 10, 1939, when a skin graft of the left orbit was performed.

The patient has been under observation from time to time since her last operation. There has been no evidence of extension or metastasis.

Microscopic examination: The section consisted of sheets and a number of irregularly arranged nests of cells. There was a moderate amount of pigmentation. The cells contained a variable amount of cytoplasm. The nuclei were irregular in size, many were quite large. A diagnosis of malignant melanoma was made.

Melanoma of the Eye, Intra- and Epibulbar

Colonel J. E. Ash read a paper based on 1,600 old melanomas collected in the Registry of Ophthalmic Pathology at the Army Medical Museum. The striking facts from data of 1,500 malignant melanomata of the uveal tract are its rarity in the colored race, the predominance in the choroid, and its occurrence in older people. Recurrence in orbital tissue is not common, suggesting that postoperative irradiation is unnecessary. The two commonest clinical symptoms are retinal detachment and glaucoma. From the number of small flat melanotic tumors found in eyes removed for other causes, one may conclude that a certain percentage of these tumors remain quiescent.

Tumors of the iris may be treated more conservatively either by observation or iridectomy, but not by irradiation.

One of the most valuable things that have come out of the Registry is Callender's classification by cell type. More recently, a study has been made to determine if there is any prognostic significance in the argyrophil-fiber content of these tumors. A classification by pigment content of 450 cases of intraocular malignant melanomata followed five years or more is given (see this Journal, 1942, Aug., p. 962).

Epibulbar melanomata are also dealt with, and these also rarely affect the Negro. It would seem that these may be treated more conservatively, especially where local complete excision is practicable. Here again it is felt that irradiation is contraindicated. It seems that the prognosis is definitely better in those tumors that have invaded the cornea than in those that have extended posteriorly into the subconjunctival and episcleral tissues.

D. W. Smith,
Secretary

LOS ANGELES SOCIETY OF OPHTHALMOLOGY AND OTOLARYNGOLOGY

March 25, 1941

Dr. Harold Mulligan, *president*

Tumors of the Caruncle

Dr. J. P. McBride read a paper on this subject. He first presented a comprehensive review of the literature, especially emphasizing the fact that a comparatively small number of these cases have been reported. He described the case of a patient recently operated on, in which the histologic section showed much fatty tissue, apparently a simple hypertrophy.

This was illustrated by excellent photographs as was also the second case, that of a benign melanoma also of the caruncle.

Heterogeneous conjunctival implants

Dr. O. H. Ellis gave a preliminary report of some research work by Dr. Meyer Wiener and himself on heterogeneous conjunctival implants. Experimenting on rabbits they have found that specially prepared cow conjunctiva will apparently act as the framework for the ingrowth of the new conjunctiva after the cul-de-sac had been denuded. The possibility presented was that heterogeneous implants could be used wherever mucous-membrane grafting was necessary. Advantages listed were ease of handling and lack of foul discharge (as is now present in skin grafts to the orbit).

Discussion. Dr. Harold F. Whalman commented that this contribution was particularly illuminating on account of the lack of success which had been experienced in the use of homogeneous skin grafts. Plastic surgeons have found that with few exceptions autogenous grafts are the only successful transplants of the skin. One would have suspected that skin derived from the more primitive embryologic structure, the ectoderm, would have been more acceptable. With reference to mucous-membrane transplants, in his experience transplants from the lower lip proved to be satisfactory in most cases where it was necessary to supplement or supplant the conjunctiva following symblepharon, excision of conjunctival tumors, and surgery upon the lids. A very large piece of membrane can be excised from the lower lip by using a long-blade cataract knife, making a puncture in the center of the area to be excised, and carrying the incision to either side before excising the graft. In this manner there is no trauma to the transplant. The lower lip epithelializes without difficulty just as the tonsillar fossas do, no sutures being necessary. Heterogeneous implants would be a distinct advantage on account of the availability of large pieces of material to cover extensive surfaces when needed, such as following exenteration of the orbit, pemphigus of the conjunctiva, or other extensive symblepharon. He expressed the hope that someone would soon have the opportunity to try these special heterogeneous grafts in cases of human defects.

Harold F. Whalman,
Editor.

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LIGHT TO PREVENT BLINDNESS

The oldest operation known to ophthalmic surgery, removal of cataract, was done to prevent blindness. But there is still much to be learned about the prevention of blindness. Glaucoma operations were done for relief of pain, but soon became more important when it was known that they could prevent blindness. The idea that prevention is better than cure grows slowly, with the experience of the race. The wide use of glasses has come with the general understanding that they may preserve the health of the eyes. Health is better than disease, and should be preserved, even when disease may be curable.

Health is assumed to be the proper inheritance of each person. It is not much thought about until it is lost. Blindness by eye disease or deformity attracts more attention than good sight. A recent report to the National Society for Prevention of Blindness showed that in certain states, where schools for the blind had been established, there were children who had useful vision, 20/50 or even better, who were being taught laboriously to read Braille. They were straining their eyes to learn to see the Braille dot; when they were able much more easily to read letters of appropriate size for primers. In these states the need of schools for the blind had been appreciated. But there was no good common school system that gave every child a chance to learn to read.

Children who had no convenient school, and might have some trouble about seeing, were sent to the school for the blind. These children were becoming blind by the process of learning to read, as the blind read, by a touch system.

The prevention of blindness requires that children should not be made even partially blind by failure to provide the proper opportunity for learning to read by sight. The prevention of blindness is now hindered by lack of general understanding of the conditions for good and easy seeing, especially by ignorance of the needful conditions for all good sight. Conditions of health are less understood than the dangers of disease.

Good light is so common out of doors that it has not been recognized that it is more needed in the schoolroom than new methods of teaching, or improved school furniture. What is good light in the schoolroom? It is light that will make easily visible, and recognizable, the printed letters commonly used in school books. This is not the light that falls on a certain window space, but the light that falls on the book, as commonly held for study. It can be estimated by use of a light meter. The light meter may well be used to demonstrate a good light to teachers or parents. But the adequacy of light may also be demonstrated by measuring the distance at which the letters in a textbook are easily recognized. A more definite idea of what is a good light may be acquired by anyone who will try reading fine print in different positions, where the amount of light falling on the page varies and may be changed by altering the position with reference to the direction from which the light will fall on the page.

In a recent publication of the National Society for the Prevention of Blindness 35 to 50 foot-candles is mentioned as a light sufficient for reading. This might be true for large, clear type, printed on good book paper, but would be very misleading for the great mass of readers, who read newspaper print, on the quality of paper used for the big daily papers. For that kind of reading, 100 foot-candles is the least that should be spoken of as sufficient. Outdoor light from the sky, or even direct sunlight on what is to be read, will be much safer than the light that is available in most schoolrooms. A light of 100 foot-candles, falling squarely upon the page to be read, should be provided in every part of every schoolroom.

The prevention of blindness is the prevention of partial blindness as well as complete blindness, needing the arm of another person to lean upon, or a walking-stick to feel the way. Poor sight, partial blindness, is very much more common than complete blindness. It is the greater field for prevention. Partial blindness begins with insufficient lighting. We may hope the time will come when the provision of good light in the schoolroom will be regarded as more important than the architectural appearance and economical construction of school buildings. A good beginning could be made by supplying 100 foot-candles of light on every desk through every school hour. To architects and school boards this may seem very revolutionary. But it would be a very reasonable and important step in the prevention of blindness. It would teach every child how easy it is to read or write, or cipher with a good light; and such a standard of good lighting would soon influence the whole community.

Edward Jackson.

MAGNETIC SPLINTERS DOUBTFULLY INTRAOCULAR

Penetration of a fragment of iron or steel into the deeper structures of the eye is always a serious accident. However kindly the eye may for a time accept the presence of the foreign material, reten-

tion of the latter is almost certain to lead sooner or later to deterioration of vital tissues; while, on the other hand, apparently easy and uncomplicated removal of the foreign body may be followed, months or years later, by retinal detachment.

It has been occasionally argued that, in view of the possibilities of late complication following removal, the risk of retention is not greater than the danger involved in surgical intervention. Yet the great majority of ophthalmologists favor extraction of the offending fragment, with either the giant or the hand magnet.

With the giant magnet, the aim is usually to entice the foreign body into the anterior chamber, with a minimum of traumatism to the iris and lens, and then to complete the action by magnetic attraction through an opening into the anterior chamber.

Some workers still prefer the anterior route, using the giant magnet, to the posterior route, in which the sclera is incised as near as possible to the foreign body, and the particle is withdrawn through the incision by means of the hand magnet.

The severest criticism which has been leveled against the use of the magnet through a scleral incision is that an important number of cases so treated show ultimate loss of vision from retinal detachment. This usually late complication is generally attributed to incidental damage to the vitreous, and several modifications of technique have been suggested with a view to reducing the amount of traumatism to that apparently inert but actually very sensitive tissue. Thus, Sherman inserts parallel intrascleral sutures and then cuts through the sclera between these sutures without entering the choroid. It is argued that avoidance of operative incision into the vitreous minimizes the danger of secondary retinal detachment.

The development of X-ray diagnosis has rendered possible a great deal of refinement in the localization of metallic foreign bodies within the eye, particularly in cases where damage to the crystalline lens interferes with ophthalmoscopic visibility. In the United States, the most popular of the X-ray techniques employed for this purpose has been that associated with the name of the late Dr. W. M. Sweet. In the hands of a skillfull roentgenologist the position of the metallic particle is often furnished with remarkable and gratifying accuracy, particularly advantageous where the operator favors use of the hand magnet and wishes to incise the sclera as near as possible to the position of the foreign body.

Only quite rarely does the roentgenologist who has thoroughly mastered the Sweet technique disappoint us as to accurate and reliable localization. The most important difficulty arises when the foreign body lies in the vicinity of the sclera on the side of the eyeball opposite to the point of entrance, and when it may or may not have passed through the sclera to lie in the loose orbital tissue.

Experience has shown that the orbital tissues are not affected in any great degree by the presence of a splinter of steel. It is also notoriously difficult to extract a small foreign body from the depth of the loose tissue, and such an attempt might easily involve danger of infection. Where, therefore, the X-ray report definitely calculates the position of the foreign body as outside the globe, it is considered good practice to make no effort at removal.

When a decision of this kind has been arrived at, the patient commonly disappears from observation and may never be seen again by the ophthalmologist who attended him immediately after the accident. Even though the eye develops later complications, these may not necessarily be of such a character as to encourage suspicion that a fragment of steel remains

inside instead of outside the eyeball. Moreover, any loss of vision which occurs may be attributed to degenerative changes connected with the mere passage of the fragment through the vitreous and the tunics of the eye.

An interesting illustration of such uncertainties was found in the case of a man who in 1926, at the age of twenty years, was injured by a splinter of steel which passed through the cornea and the root of the iris and was demonstrated by X ray to have lodged just outside the eyeball, between the internal and inferior rectus muscles. After disappearance of a small anterior-chamber hemorrhage, the ophthalmologist suspected that a lesion seen very obliquely with the ophthalmoscope threw doubt upon the accuracy of the X-ray report. But careful repetition of the Sweet technique, at the hands of a roentgenologist who had always shown great accuracy in this procedure, yielded the same result as the first examination. It was decided that the fundus appearance could represent a lesion of the retina and choroid, with a sharp line corresponding to the place at which the steel splinter had passed through the sclera into the orbit.

After the first two or three days the patient's return visits were "few and far between." Nearly ten months after the accident, central vision was reduced to 20/24 partly. In another nine months there was a well-developed cataract, with absence of ophthalmoscopic fundus reflex, although the pupil reacted vigorously to light.

In June, 1932, six years after the injury, the tension of the blind eye, previously recorded as normal, had risen to 42 mm. (Schiötz), but was gradually controlled by eserine. The patient, on his own initiative, discontinued the use of eserine three months later, but the tension was approximately normal in January, 1933. In July, 1939, the patient ran the point of a lead pencil into the cornea of the blind eye, and when seen by the writer four days later the eye showed tension of 69 mm. This severe disturbance was apparently due to acute swelling of the cataractous lens.

After an unsuccessful attempt to grasp with capsule forceps, the lens was easily expressed in its capsule, but the capsule burst the moment the lens was laid on the instrument table. Two weeks later the eye was again hypertensive, and, having failed to respond to other methods, it was enucleated by a colleague during the writer's absence from the city.

A study of the enucleated eyeball at the Army Medical Museum disclosed within the vitreous the fragment of steel which thirteen years earlier we had satisfied ourselves was outside the eyeball.

Again in a second case, seen by a colleague who kindly consents to its being mentioned here, the fragment of steel was reported to lie outside the globe. The eye gradually became cataractous and blind, and after about a year showed a suspicious change in the color of the iris. A new X-ray investigation, by the roentgenologist who had reported on the eye in the first place, showed a foreign particle in the vitreous close to the ciliary body. The fragment was easily removed with the hand magnet through a scleral incision. Presumably the foreign body had been carried forward to its new position by a detached retina.

In each of these cases, exploratory use of the electromagnet might have seemed undesirable because it would expose the eye to the risk of retinal detachment, and such an intervention appeared unnecessary by reason of the report from an eminently trustworthy roentgenologist. But in each case it is likely that such an exploratory procedure would have removed the foreign body from the eye. In the first case, at least, there is a fair presumption that the patient would have

had a very substantial chance of permanently retaining a visually useful eye. But in every such case the ophthalmologist's decision would be a difficult one, not without hazard for the patient.

There may even be good reason for assuming that the foreign body is more likely to lie inside than outside the sclera. Much of the projectile force of the foreign body has certainly been spent in its original passage through the sclera, and the fragment, moving at reduced speed, is likely to encounter the sclera on the other side of the globe at an oblique angle. Everything considered, it may be more conservative to handle such cases by cautious exploratory incision of the sclera and application of the magnet than by inactivity based upon the assumption that the foreign body lies outside the globe. W. H. Crisp.

CORNEAL PERMEABILITY TO DRUGS

Although it has been known for years that certain substance such as atropine (de Ruiter, 1853), eserine (von Graefe, 1863), and cocaine (Königstein), when introduced into the conjunctival sac, penetrate the cornea and enter the aqueous, it is only recently that renewed interest in the subject of corneal permeability has appeared. Cellular physiologists, in studies of cell membranes, have pioneered in work on the permeability of living tissues. It is stated by them that permeability involves four factors—mass, area, time, the concentration and specific nature of the environment (Gray). Older experiments proved that penetration of drugs into the anterior chamber was almost entirely through the cornea, with only small amounts passing through the conjunctiva (Bellarminoff, Nakamura, Wessely, Post, Antonibon). This penetration is believed to be a process of diffusion, but recently Swan and White have stated (see this issue, p. 1055) that it is not a simple matter of diffusion but a complex process. Its rate is dependent on several factors; for example, the condition of the corneal epithelium, osmotic pressure, pH of the solution, concentration of the solution, molecular structure and physical properties of the compound, nature and physical properties of the vehicle, hydrostatic pressure, and length of contact with the cornea.

The intact epithelium of the cornea has been considered to act as a barrier against the penetration of diffusible substances; however, Swan and White found the epithelium acts as a barrier to polar and surface inactive compounds but may actually facilitate absorption of nonpolar or highly surface-active substances. Therefore, it seems the epithelium is not a simple barrier limiting the penetration of all substances.

The osmotic pressure of a fluid instilled into the conjunctival sac has an influence on the corneal epithelium, hence affects permeability—for example, highly hypertonic solutions temporarily reduce penetration—then as epithelial damage develops the penetration increases (Swan). But changes in tonicity must be pronounced and contact with the cornea prolonged, otherwise absorption is unaffected.

The pH of a solution affects the rate of passage through the cornea; for example, procaine in acid solution (pH 5-7) exists as a free cation, having the characteristics of a polar compound, and penetration is slow. But when in alkaline solution, with characteristics of a nonpolar compound, free base is liberated and penetration is rapid.

The concentration of the solution up to a certain point has a bearing on penetration; that is, the more concentrated the greater the penetration.

While the molecular size is not of great

importance, the molecular structure and physical properties of a compound affect the penetration rate. The relationship between polar and nonpolar components of the molecule is of importance, since it determines surface activity and solubility (Swan and White).

The nature and physical properties of the vehicle carrying the compound affect the penetration rate. If the drug has great affinity for the vehicle, diffusion is slow.

Cogan and Kinsey have found that the hydrostatic pressure influences the transfer of fluids through the cornea, the amount of fluid passing through the cornea being directly proportional to the hydrostatic pressure employed.

It has been believed that transmission through the cornea is more rapid in the presence of reduced intraocular pressure and slower if the intraocular pressure is elevated, but recently Swan and White found that rapid variations in intraocular pressure do not influence penetration unless there is epithelial damage.

The time element is important, naturally—the longer the drug is in contact with the cornea, the greater the penetration.

C. S. O'Brien.

PIGMENTED TUMORS OF THE EYE AND ADNEXA

The subject of pigmented tumors of the eye and adnexa is large, complex, confusing, and controversial. It necessarily follows that the terminology used is not standard and is often inaccurate, so that references to given lesions do not mean the same to all without at least qualifying statements.

Malignant melanoma is the term most generally used for this primary malignant tumor of the uveal tract. Whether such tumors are mesodermal (melanosarcoma), ectodermal (melano-epithelioma or melanocarcinoma), or neurogenic in origin is not generally agreed upon, so that the term *malignant melanoma* carries no implication with it. A confusion, though, arises here sometimes because the same term is used for another type of tumor occurring elsewhere in the body (a better term for this tumor would be *cancerous melanosis*), which has different clinical and histologic characteristics and with a mortality of almost 100 percent compared to the 50 percent mortality of those arising in the uveal tract. For this reason ophthalmologists are sometimes censored by men in other specialties for not doing an exenteration instead of an enucleation in a case of malignant melanoma of the uveal tract, for the most radical surgery in cases of malignant melanoma elsewhere is not even adequate. An enucleation is indicated for such tumors of the uveal tract, for a local recurrence is an extreme rarity and would probably be even rare if the surgeon at the time of enucleation considered the possibility of an extraocular extension and dealt with it accordingly.

A common occurrence in the uveal tract is a localized accumulation of melanoblasts. These are frequently seen in the choroid and less often in the ciliary body and iris. This lesion should be termed a *benign melanoma.* They are sometimes called a nevus but incorrectly, for they contain no nevus cells. Malignant melanomas of the uveal tract seem to originate from benign melanomas.

The localized, elevated, congenital, potentially pigment-bearing tumors of the conjunctiva and skin are nevi. They are composed of the so-called nevus cells and are generally thought to be neurogenic. They practically never give rise to a malignant tumor, but when they do the tumor is a localized, maybe pedunculated mass, and the term *malignant melanoma* seems to be the best. They have clinical and histologic characteristics of the malignant melanoma arising in the uveal tract.

The diffuse nonelevated acquired pigmentation of the conjunctiva and/or the adjacent skin should be called *precancerous melanosis*. These tumors arise from the basal layer of the epithelium and usually develop into a highly malignant tumor which should be called *cancerous melanosis*. A cancerous melanosis of the conjunctiva and skin is at least five times more common than a malignant melanoma arising from a nevus. The mortality, also, of the cancerous melanosis is greater.

There are two other rare and related pigmented lesions, usually of the skin, but the writer believes there are also instances of their occurrence in the conjunctiva. These are called extrasacral mongolian spot and blue nevus, or Jadassohn nevus. In higher mammals there is an independent network of branching melanoblasts situated in the deeper layers of the cutis. This system is normally rudimentary in man in the sacral region (mongolian spot) not only in the Mongolian but also in the Caucasian race and at least microscopically in every one. As an atavistic rest of this subcutaneous-pigment system there may appear, more often on the face or extremities, a pigmented lesion with a bluish color, due to the fact that the lesion is deep in the cutis with a pigment-free layer of stroma between it and the epithelium. Such a lesion is called an extrasacral mongolian spot. If a localized tumor formation arises from this rudimentary cutaneous-pigment system, it is called a blue nevus or Jadassohn nevus. If a malignant tumor arises from such a lesion, it is called a melanosarcoma. The type cell in the benign manifestation of this lesion resembles the melanoblast of the uveal tract. There are no nevus cells as the name implies.

The lesions that have been discussed vary in regard to the clinical and histologic characteristics, but they all have the one element of pigment in common. They all contain pigment-producing rather than pigment-harboring cells and therefore are dopa-positive. Whether pigment is present clinically or even microscopically is not decisive because its presence depends on whether or not the premelanin in the melanoblast has changed to melanin, a transition due to a chemical reaction based on oxidation. Sometimes a congenital nevus is first noticed, or is thought to have taken on active growth, in later life. This apparent acquisition of or increase in growth of a nevus seems to be due in most instances not to actual growth but to the increase in the pigment content of a preëxisting nevus which, on the one hand, was formerly nonpigmented, or, on the other hand, formerly only partially pigmented.

There are instances of melanosis not mentioned above because they cannot be properly included under the subject of tumors. One is the congenital melanosis of the conjunctiva (sometimes skin) characterized by a localized area of pigmentation usually adjacent to the limbus in an otherwise normal-appearing conjunctiva. The pigment is in the basal layer of normal conjunctiva, which layer is a potentially pigment-bearing tissue and in highly pigmented individuals and races this melanosis is seen in a diffuse form. Another is the condition of melanosis oculi, which is an increase in the pigmentation of all the potentially pigment-bearing tissue in and around one eye as compared with the fellow eye. Also, a melanosis may occur in the skin overlying an area of neurofibromatosis.

The pigmented epithelium in the eye is the most proliferative tissue of all. It proliferates under slight provocation in all types of intraocular lesions and sometimes in enormous amounts. It is surprising therefore that, practically speaking, this tissue never gives rise to a new-growth.

Nine types of benign and malignant pigmented growths of the eye and adnexa

have been enumerated here. These seem to have different clinical and histologic characteristics, with only the element of pigment in common. Because of this one and striking common factor we are prone to call them all nevi or melanomata, and frequently these two terms are used interchangeably. There is a pathology committee functioning in some of the national ophthalmological societies. If one of these committees would take on the task of recommending a standard nomenclature for pigmented tumors encountered in ophthalmology, it would be quite welcome. They would not only help in the discussion of these tumors but also in the proper cataloguing of them in the literature.

Algernon B. Reese.

BOOK NOTICES

BIOLOGICAL SYMPOSIA, A Series of Volumes Devoted to Current Symposia in the Field of Biology. Edited by Jaques Cattell. Volume VII, Visual Mechanisms, edited by Heinrich Klüver. Clothbound, 322 pages. Lancaster, Pennsylvania, The Jaques Cattell Press, 1942. Price $3.25.

This is a notable collection of theses on visual mechanisms. Some of them are quite involved and will be beyond the appreciation of most ophthalmologists because of their technical nature. This, however, obviously is not a criticism of their intrinsic value. Only a few of them will be discussed in this review, at the end of which will be listed the titles and authors of those not mentioned in the editorial.

The first article, by Prof. Selig Hecht, is one of the technical essays, having to do with energy requirements for vision. The last paragraph of the summary epitomizes this study: "The results clarify the nature of the fluctuations shown by an organism in response to a stimulus. The general assumption has been that the stimulus is constant and the organism variable. The present considerations show, however, that at the threshold it is the stimulus which is variable, and that the properties of its variation determine the fluctuations found between response and stimulus."

The photochemistry of visual purple is discussed by Dr. A. C. Krause. This is for the most part a very technical article, with a number of involved chemical formulas which indicate the general structure of the chromophoric group in visual purple. The similarity of the structure of visual purple and dyes used to sensitize photographic emulsions is shown.

Dr. E. Gellhorn has a short chapter on anoxia in relation to the visual system. He summarizes as follows: "Relatively mild degrees of anoxia result in a marked diminution of various visual functions such as intensity, discrimination, visual acuity, dark adaptation, color perception, etc. The effects are reversible on readmission of air. . . . Since the brain consumes glucose almost exclusively it is to be expected that the glucose level as well as the oxygen tension of the blood would determine the rate of oxidations in the brain. This can be illustrated by the study of visual dark adaptation as McFarland has shown. These reactions seem to be based on general characteristics of the cortex, since it could be shown that the effect of hypoglycemia on the E.E.G. is aggravated by the inhalation of low oxygen, and is offset by the inhalation of 100 percent oxygen."

To the ophthalmologist interested in histology, the paper by Gordon L. Walls will be significant, as it traces the comparative anatomy of the visual cells beginning with the lower animals and extending to the mammalians. Excellent illustrations accompany the article.

TITLE	AUTHORS
Visual systems and the vitamins A	Dr. George Wald
Visual sensation and its dependence on the neurophysiology of the optic pathway	Dr. S. H. Bartley
Alpha waves in relation to structures involved in vision	Dr. T. J. Case
Recent evidence for neural mechanisms in vision leading to a general theory of sensory acuity	Drs. W. H. Marshall, S. A. Talbot
The functional organization of the occipital lobe	Drs. G. v. Bonin, H. W. Carol, and W. S. McCulloch
Anatomy of the retina	Dr. S. L. Polyak
Functional significance of the geniculo-striate system	Prof. H. Klüver
The problem of cerebral organization in vision	Prof. K. S. Lashley

Lawrence T. Post.

THE CARE OF THE AGED (GERIATRICS). By Malford W. Thewlis, M.D. Clothbound, 589 pages, illustrated, octavo. Saint Louis, C. V. Mosby Company, 1942.

The word geriatrics was first used, in 1909, by I. L. Nascher, M.D., to whom this book is dedicated. Geriatrics deals with defects and disease as they appear in old age. Hippocrates wrote a list of diseases to which old persons are subject, including in it dimness of sight, cataracts, and glaucoma. Roger Bacon in the thirteenth century wrote a book on old age, which lay among his manuscripts and was not translated into English until 400 years later. This is the fourth edition of a book first published in 1919.

Its first 4 chapters are headed: History of geriatrics, Neglect of the aged, The value of old age, and Hygiene (Gerocomia). In chapter IV we find the statement: "Special care should be given to the eyes; an ophthalmologist should correct errors of refraction. The aged are better when they can read easily and forget themselves." Chapter XXXII is devoted to the Special senses. The section on the eye is written by Dr. A. Ray Irvine of Los Angeles; the section on the ear by Dr. Harold R. Mulligan of Hollywood, California. These will be interesting and suggestive to all readers.

If geriatrics is to be a special branch of medicine, it will be more like general practice than any other special branch. It is something that both physician and surgeon need, for practical application. Life is an irreversible process. The young doctor, or the busy practitioner, gets little light on it from his own experience. Geriatrics has not been taught nor emphasized in the regular medical curriculum. To read a book about it, and apply what is there learned to the needs of his old patients, is the practical way to master it. This is a very good book with which to start.

The practical point of view with regard to geriatrics is indicated by most of the chapter headings: Prolonging life, Work for the aged, Nutrition in old age, Rest and exercise, and Nursing the aged patient. A section of 20 pages is devoted to Allergy, Alcoholism, and Focal infection. There is a chapter on Cancer, and the last chapter, 21 pages, treats of the Surgery of the aged. When one has looked over the book, one no longer wonders why a book on such a new subject has already reached its fourth edition.

Edward Jackson.

ABSTRACT DEPARTMENT

EDITED BY DR. WILLIAM H. CRISP

Abstracts are classified under the divisions listed below, which broadly correspond to those formerly used in the Ophthalmic Year Book. It must be remembered that any given paper may belong to several divisions of ophthalmology, although here it is mentioned only in one. Not all of the headings will necessarily be found in any one issue of the Journal.

CLASSIFICATION

1. General methods of diagnosis
2. Therapeutics and operations
3. Physiologic optics, refraction, and color vision
4. Ocular movements
5. Conjunctiva
6. Cornea and sclera
7. Uveal tract, sympathetic disease, and aqueous humor
8. Glaucoma and ocular tension
9. Crystalline lens
10. Retina and vitreous
11. Optic nerve and toxic amblyopias
12. Visual tracts and centers
13. Eyeball and orbit
14. Eyelids and lacrimal apparatus
15. Tumors
16. Injuries
17. Systemic diseases and parasites
18. Hygiene, sociology, education, and history
19. Anatomy, embryology, and comparative ophthalmology

1

GENERAL METHODS OF DIAGNOSIS

Jackson, Edward. **To measure the pupil.** Amer. Jour. Ophth., 1942, v. 25, July, p. 871.

2

THERAPEUTICS AND OPERATIONS

Adson, A. W. **Surgical treatment of vascular diseases altering the function of the eyes.** Amer. Jour. Ophth., 1942, v. 25, July, pp. 824-838; also Trans. Amer. Acad. Ophth. and Otolaryng., 1941, 46th mtg., p. 95. (11 figures, bibliography.)

Dekking, H. M., and Bylweld, J. P. **Non-irritating collyria.** Ophthalmologica, 1942, v. 103, Jan., p. 40.

Collyria are non-irritating when they are isotonic with the tissue juices and when they have a proper pH. The former factor is easily adjusted and moreover is not critical. The pH varies greatly from patient to patient but is constant within narrow limits in the individual patient, if the reaction of the tears is a reliable criterion. Citric acid is an excellent substance for adjusting the pH, as are also the "sugar acids," such as gluconic, saccharonic, and lactobionic. In the compounds with the therapeutic metals, the metallic ion is loosely bound so that it is readily available. A buffer may be added.

F. Herbert Haessler.

Schmid, A. E., and Saubermann, G. B. C. **Sulfanilamide therapy in ophthalmology with Irgamid.** Ophthalmologica, 1942, v. 103, Feb., p. 65.

The authors report observations made in the course of considerable clinical experience and also an extended experimental study of the properties of the drug investigated, which was tolerated even by very old patients. As reported before (Amer. Jour. Ophth., 1941, v. 24, Oct., p. 1214) it was most effective in corneal ulcers, both serpiginous and catarrhal, gonoblennorrhea neonatorum, intraocular infection, lid phlegmon, and dacryocystitis. The optimum doses are reported.

F. Herbert Haessler.

Young, J. H. **Clinical observations and deductions in the therapeutic use of sulfonamide and its derivatives in ophthalmology.** Brit. Jour. Ophth., 1942, v. 26, June, p. 241.

For traumatic lesions of the conjunctiva and cornea, red prontosil soluble, by instillation in the conjunctival sac in 2.5-percent solution, brings about rapid epithelial regeneration and controls secondary infection. It is also valuable for preoperative instillation in the conjunctival sac, and in treatment of blepharitis, conjunctivitis, marginal ulcer, and infected socket. No contraindications or incompatibilities were found to exist. By internal administration the drug controlled both specific and nonspecific iritis, prehypopyon ulcer, episcleritis, cellulitis, intraocular infections, and trachoma. (12 case histories.) Edna M. Reynolds.

3

PHYSIOLOGIC OPTICS, REFRACTION, AND COLOR VISION

Cowan, Alfred. **Myopia.** Amer. Jour. Ophth., 1942, v. 25, July, pp. 844-848; also Trans. Amer. Acad. Ophth. and Otolaryng., 1941, 46th mtg., p. 197. (References.)

Moncreiff, W. F., and Scheribel, K. J. **Further studies concerning homatropine cycloplegia and paredrine, with special reference to the rate of accommodative recovery.** Amer. Jour. Ophth., 1942, v. 25, July, pp. 839-843. (3 tables, 10 figures.)

Neblett, H. C. **Spectacles in our armed forces in war.** Southern Med. and Surg., 1942, v. 104, May, p. 278.

The lowering of visual requirements for the armed services will greatly increase the number of soldiers dependent upon glasses. The author suggests that anyone going into active military duty should have an extra pair of spectacles as a necessary part of his equipment. A copy of the prescription including frame measurements should be carried. Rimless glasses are to be strongly advised against, as they are more easily broken and do not protect as well. A presbyope with good distant vision should carry a suitable monocle for emergency use. John C. Long.

Schlaer, S., Smith, E. L., and Chase, A. M. **Visual acuity and illumination in different spectral regions.** Jour. Gen. Physiology, 1942, v. 25, March 20, pp. 553-569.

The relation between visual acuity and illumination was measured in red and in blue light, using a broken circle or C and a grating as test objects. The results do not lend themselves to abstracting. T. E. Sanders.

4

OCULAR MOVEMENTS

Daily, R. K., Daily, L., Walker, J. D., and Peterson, H. J. **Exophthalmic ophthalmoplegia.** Southern Med. Jour., 1942, v. 35, April, p. 344. (See Section 13, Eyeball and orbit.)

Feldman, J. B., and Taylor, A. F. **Obstacle to squint training—amblyopia.** Arch. of Ophth., 1942, v. 27, May, pp. 851-868.

In an effort to arrive at some conclusion as to the reason for the variable results obtained in cases with amblyopia, 68 patients were studied. These were divided into four groups: (1) children with amblyopia and squint, (2) children without squint, (3) adults with amblyopia, and (4) a miscellane-

ous group including patients with normal eyes and those who had had amblyopia and whose vision improved to 5/5 with glasses. Fifty percent of the patients were children treated for amblyopia or squint in the orthoptic clinic. The balance were adults encountered in private practice and children who came to the ophthalmic clinic for refraction. The findings are tabulated and discussed as to heredity, age and sex, refraction, vision, acuity tests, field of vision, suppression, ophthalmoscopic findings, angle of squint, grades of binocular vision, associated obstacles (such as false projection) and prognosis. The authors found that the testing of the vision with different visual charts may elicit different values for visual acuity. If the variation is slight, it may be due to the fact that what appeals to the eye is read more easily. However, if the variation is marked, the cause probably lies in the use of different fixations in reading the chart. The incidence of scotoma in this series was not as high as that often mentioned in the literature but suppression areas were common. These areas were not always constant, and might be found associated with squint without amblyopia. They are valueless as a basis for an opinion as to diagnosis or prognosis. A difference in the angle of squint was often obtained, even though measured objectively, using both the synoptophore and the perimeter. Since adults with amblyopia presented the least tendency to cultivate even the first grade of binocular vision, and children with ambloypia without squint showed the best results, achieving even the third grade of binocular vision, the authors point out that amblyopia should be recognized early and every effort made to correct the condition.

J. Hewitt Judd.

Lancaster, J. E. **The orthoptic treatment of alternating squint.** Amer. Jour. Ophth., 1942, v. 25, July, pp. 866-870.

Montalván, Plinio. **Duplex rod with handle for routine investigation of extraocular muscles.** Arch. of Ophth., 1942, v. 27, May, pp. 1005-1008.

In order to facilitate examination of the muscle balance in six diagnostic positions, two large multiple red rods about 65 mm. in diameter are mounted on the ends of a bakelite handle 15 cm. long. These multiple rods are oriented in directions respectively perpendicular and parallel to the handle, so that each may be held alternately in front of the eye to make the position of the red lines suitable for the study of horizontal and vertical imbalances. The author points out the necessity of examining the muscle balance in the six diagnostic positions, since individual muscular overaction and underaction, particularly of the vertical rectus and the oblique muscles, while giving rise to considerable asthenopia may not cause any heterophoria in the primary position, the deviation being present only in the field of action of the affected muscle. J. Hewitt Judd.

Stutterheim, N. A. **Involuntary convergence, eyestrain, and squint.** Brit. Jour. Ophth., 1942, v. 26, May, pp. 216-225.

The author believes that the main solution to the great problem of eyestrain and squint lies in establishing a full normal range of convergence, which can be done by kinetic treatment for asthenovergence with the battery of prisms. The paper describes the scope and results of kinetic treatment. The author points out that mechanizing kinetic treatment may involve eventu-

ally a danger of its passing into the hands of unqualified persons.

Edna M. Reynolds.

5

CONJUNCTIVA

Bolettieri, Daniele. **The value of cutireaction with extracts of proteus communis and proteus X 19 in trachoma.** Boll. d'Ocul., 1940, v. 19, April, pp. 333-339.

Tests made by intradermal injections of proteus in 125 patients, 75 of them affected by trachoma in different stages, indicated that the marked reaction obtained in some of the patients had the same character in trachomatous as in nontrachomatous patients. This reaction is to be regarded as nonspecific; it has no diagnostic value and does not illuminate the question whether trachoma should be considered a rickettsia disease. (Bibliography.) M. Lombardo.

Castelli, A., and Molina L. **"Parinaud's conjunctivitis."** Ann. di Ottal. e Clin. Ocul., 1940, v. 68, Feb., pp. 81-127; and March, pp. 179-239.

This monograph is introduced by a detailed, comprehensive, and systematic review of previous studies and of published cases. The present state of knowledge is set forth under the heads of general notes, symptomatology, course, prognosis, therapy, outcome, pathologic anatomy, and etiology. The authors then report in detail a case of their own, which served as the basis for extensive cultural and pathologic studies. Pirquet's reaction was positive for human, bovine, and avian strains. The seroreaction with five strains of Bacillus pseudotuberculosis rodentium was negative. An organism very similar to Koch's bacillus was isolated and cultured. Its pathogenic properties were tested for guinea pigs, rabbits, calves, chickens, and rats, and were found to be positive in all except the last two. The changes in the organs of the experimental animals were considerable but were not unequivocally tuberculous. Instillation of the organism in the conjunctival sac of a human being produced swelling, conjunctival injection, and follicles. The authors reach the conclusion that the rod isolated by them is a newly discovered etiologic agent, which may be of animal origin, and for which they propose the name "microbacterium conjunctivitidis Parinaudi (Castelli and Molina)." They consider that Parinaud's conjunctivitis is not a syndrome but a disease sui generis. Harry K. Messenger.

Grancini, E., and Ferdinando, R. Di. **The p_H of conjunctival exudate in various forms of conjunctivitis.** Boll. d'Ocul., 1940, v. 19, April, pp. 289-317.

The p_H of conjunctival secretions in all forms of trachoma, catarrhal conjunctivitis, suppurated chalazion, mucopurulent dacryocystitis, gonococcus conjunctivitis, and other conditions, is tabulated. The more purulent the secretion becomes, the more the alkalinity decreases. The secretion of gonococcus conjunctivitis is acid. (Bibliography, 2 figures.) M. Lombardo.

Lee, O. S., Rottenstein, H. S., and Chao, H. Y. **Local treatment of trachoma with sulfanilamide.** Chinese Med. Jour., 1941, v. 60, Sept., pp. 207-221.

The authors applied the sulfonamides to a number of trachomatous eyes, using several different methods. Sulfanilamide brossage reduced the follicles of trachoma but showed no advantage over brossage with boric-acid

powder. Subconjunctival injections of neoprontosil apparently had no specific effect. Ointments of sulfanilamide and prontosil were no more effective than any other bland ointment. Solutions of sulfanilamide and neoprontosil were ineffective as eye drops. The prolonged application of sulfanilamide powder to the conjunctival sac was of value in corneal ulcers but not so effective as oral administration. Numerous determinations of sulfanilamide content in the aqueous were made after local application. Very high concentrations were obtained except in the cases exhibiting gross pannus. The authors conclude that a concentration of 3 to 4 mg. per hundred c.c. in the aqueous as obtained by oral administration of sulfanilamide is the most effective in the treatment of trachoma. The much higher, but transient, concentrations obtained by local instillations of the powder are not so effective.

John C. Long.

Levitt, R. O., and O'Neil, H. B. **Cutaneous and conjunctival manifestations of sulfathiazole intoxication.** Jour. Amer. Med. Assoc., 1941, v. 116, March 8, p. 938.

The authors report seven patients with sulfathiazole intoxication in which conjunctivitis was frequently encountered. Conjunctivitis may accompany a rash or may appear as an isolated phenomenon. Cessation of the drug is immediately indicated.

George H. Stine.

Rake, G., Shaffer, M. F., and Thygeson, P. **Relationship of agents of trachoma and inclusion conjunctivitis to those of lymphogranuloma-psittacosis group.** Proc. Soc. Exper. Biol. and Med., 1942, v. 49, April, p. 545.

The authors present a table of results of complement-fixation tests on patients having these diseases. There is indication of a definite antigenic relationship between the agents of both trachoma and inclusion conjunctivitis and those of the lymphogranuloma-psittacosis group. F. M. Crage.

Ré, B. V., and Muhlmann, V. **Primary diphtheric conjunctivitis in the new-born.** Arch. de Oft. de Buenos Aires, 1941, v. 16, May, p. 261.

A case of bilateral pseudomembranous conjunctivitis in a 17-day-old infant is reported. There was marked edema of the lids, with considerable bloody mucopurulent discharge. The tarsal conjunctiva was covered by pseudomembranes but no nasal or pharyngeal involvement was present. Bacteriologic examination of the conjunctival exudate revealed the presence of Loeffler bacilli. Antidiphtheric serum was given both locally and hypodermically. The ocular condition rapidly subsided and a complete cure was obtained by the fifth day of treatment.

The authors emphasize the rarity of primary diphtheric infection of the conjunctiva and present a brief review of the literature. (Bibliography.)

Plinio Montalván.

Sorsby, Arnold. **The etiology of phlyctenular ophthalmia.** Brit. Jour. Ophth., 1942, v. 26, April, pp. 159-179; and May, pp. 189-215. (See Section 6, Cornea and sclera.)

Sory, Robert. **Sulfanilamide in the treatment of trachoma.** Amer. Jour. Ophth., 1942, June, v. 25, pp. 713-720. (4 tables, references.)

Stocker, F. W. **Operation for removal of pterygium.** Arch. of Ophth., 1942, v. 27, May, pp. 925-928.

After instillation of a local anesthetic and subconjunctival injection of procaine hydrochloride with epinephrine, the pterygium is grasped near its head, and dissected from the underlying corneal parenchyma as far as the limbus, beginning at the end nearer the pupillary area. The conjunctiva is incised from the limbus, outward, along each margin. The upper incision is made as long as the breadth of the pterygium at the limbus, and the lower incision about half as long as the upper one. After undermining the conjunctiva, an incision is made upward and toward the cornea at an angle of approximately 45 degrees from the end of the upper conjunctival incision, thus forming a flap. A suture is passed through the apex of this flap and is drawn down and sutured to the episclera at the limbus at the point where the lower conjunctival incision started. This prevents any shifting of the flap upward and eliminates sutures in the area formerly occupied by the pterygium. The head of the pterygium is then excised obliquely with scissors to obtain a flap with smooth edges, and eliminate the degenerated tissue of the head. The apex of this flap is then sutured into the angle made by the upper incision. The conjunctiva is closed along each edge with two or three sutures. In this way the course of the pterygium with its fibers and vessels is directed vertically, and it is separated from the limbus by a flap of normal conjunctiva. The blood vessels in the flap of sound conjunctiva covering the place formerly occupied by the pterygium have a course tangential instead of radial to the limbus. The article is illustrated by drawings.

J. Hewitt Judd.

Thygeson, P., and Stone, W., Jr. **The treatment of inclusion conjunctivitis with sulfathiazole ointment.** Jour. Amer. Med. Assoc., 1942, v. 119, May 30, p. 407.

The authors report 15 cases of inclusion conjunctivitis in infants, children, and adults, in 11 of which the local use of 5-percent sulfathiazole or sodium-sulfathiazole ointment was effective in producing rapid healing. In ten of the latter cases the epithelial-cell inclusions characteristic of the disease could no longer be found after three days of therapy. Two of the remaining four cases required supplemental oral therapy. There were no recurrences. The authors conclude that local sulfathiazole therapy would appear to be the treatment of choice in inclusion conjunctivitis, at least in the new-born.

George H. Stine.

Waldapfel, Richard. **Abscess-forming follicular conjunctivitis.** Arch. of Ophth., 1942, v. 27, May, pp. 929-933.

Two cases of infection of the conjunctiva are reported in which minute aggregations of leukocytes and streptococci occurred in lymph follicles. The pathologic process was analogous to the one encountered in acute infection of the pharyngeal lymphoid tissue. This condition differed from the types of follicular conjunctivitis thus far described, and could be appropriately designated as abscess-forming follicular conjunctivitis. In view of the findings reported and the success in the treatment of similar infections of the pharynx, administration of sulfanilamide seems to be the method of choice.

J. Hewitt Judd.

6

CORNEA AND SCLERA

Castroviejo, R., and Elliot, A. J. **Inclusion of sclera in corneal transplan-**

tation. Arch. of Ophth., 1942, v. 27, May, pp. 899-924.

The authors describe in detail their method of obtaining a corneoscleral transplant from the limbal region so that a 4-mm. square contains 3 mm. of cornea and 1 mm. of sclera. The transplantation was performed on 16 rabbits and there was a tendency in all instances toward imperfect union of the graft, a slight gaping being noted along the scleral-wound margin in its superficial layers. The epithelium over the corneoscleral graft was replaced by an uneven growth of epithelium from the recipient cornea, and the transplants invariably became opaque and vascularized. The epithelium was supported by a subepithelial layer of fibroblasts derived largely from the stroma of the recipient cornea. Behind the graft a layer of fibers was formed from the endothelium and the deep corneal fibers of the host. A rich vascular plexus surrounded the graft and sent out fine capillaries into both the superficial and the deep layers of the fibroblasts. There was a pronounced wrinkling of Descemet's membrane, but no evidence of formation of a new Descemet's membrane was observed. The original stroma of the graft could be distinguished as a mass of poorly-staining fibers with new nuclei and practically no blood vessels. It was encased largely by the subepithelial and endothelial fibroblasts. The scleral portion of the graft was diminished little in size. Irregular, spindle-shaped spaces were frequently observed within the layer of fibroblasts. The authors present an analysis of the complications encountered during the experiment, which include defective coaptation of the edges, infection, results of improper insertion of the suture, rupture of the anterior capsule of the lens, and matting of the sutures with fibrin. They conclude that the inclusion of sclera in the graft is undesirable and should be avoided in corneal transplantation in man. (Drawings, photomicrographs, photographs.)

J. Hewitt Judd.

Chamberlain, W. P., Jr. **Treatment of pneumococcic corneal lesions.** Arch. of Ophth., 1942, v. 27, May, pp. 869-886.

The author presents the results of six series of experiments conducted to evaluate the effectiveness of the oral administration of sulfapyridine in pneumococcic corneal lesions. An injection method is described for producing a standard experimental pneumococcic corneal lesion in rabbits. In the first series, treatment was not started until 18 hours after inoculation in order to allow the corneal lesions to become well established. However, in view of the severe lesions obtained and the absence of appreciable difference between the treated and the untreated animals, the therapy in series 2 was begun only thirty minutes after inoculation. In the remaining four series, the initial dose was given at least five hours before corneal inoculation, so as to bring out the maximum effect of the drug. Treatment was continued in each instance through the acute phase of the lesions, or for at least eight days. In the first series, a dose of 0.3 grams was given twice daily. Since low blood levels of sulfapyridine were obtained, the dose was increased successively in the subsequent experiments to a maximum dose of 1.2 grams, repeated twice daily. The final series is presented in detail to show the procedures followed and to illustrate the significant findings. The results obtained are summarized for three stages: (1) on the third day after inoculation, at the peak of the acute phase, (2) on the ninth day, when the reaction

was beginning to subside, and (3) at the end of three weeks, as the lesions became quiescent. In the dose employed the drug was found to have little value in controlling established ulcers. Large prophylactic doses of sulfapyridine produced a marked reduction in the reaction of the adnexa during the acute phase and seemed to be somewhat beneficial in controlling the extensiveness of the corneal lesions proper. Since repeated determination showed that in most instances the blood concentration of free sulfapyridine was well within the recommended therapeutic range, it is thought that the failure of certain pneumococcic corneal lesions to be controlled by sulfapyridine may be due to the presence of some substance in necrotic debris which counteracts the action of the drug. It is pointed out that sulfanilamide derivatives are primarily bacteriostatic rather than bacteriocidal in their action. Clinical reports are presented of six cases of pneumococcic corneal ulcer in which systemic sulfapyridine therapy was employed. In four of these the drug was apparently without effect, while in the remaining two there may have been some hastening of the convalescence and reduction in the density of the scar. J. Hewitt Judd.

Duane, J. F. **Congenital cyst of the sclera.** Amer. Jour. Ophth., 1942, v. 25, July, pp. 871-873. (2 figures, references.)

Grancini, Enrico. **A rare observation of primary adiposis of the cornea in a girl who was affected by hypophyseal infantilism and diabetes insipidus.** Boll. d'Ocul., 1940, v. 19, April, pp. 267-288.

A girl of 19 years, affected by general symptoms of hypophyseal origin, showed a reniform flat yellowish mass covering the limbus from the six-o'clock to the ten-o'clock position, extending 3 or 4 mm. onto the sclera, and reaching the middle layers of the corneal stroma. Conjunctival and episcleral injection was a marked feature of the disturbance. The other eye, which according to the patient had shown a similar lesion, had been enucleated. Histologic and histochemical examinations of the removed neoformation are described. In discussing these findings the writer expresses the opinion that the primary adiposis is a part of the lipoidosis. Inasmuch as this lesion has been found to affect patients manifesting diseases of endocrine origin, the writer thinks that the changes in lipoid metabolism which give rise to the lipoidosis are of hormonic origin. M. Lombardo.

James, W. M. **The surgical removal of corneal scars.** Amer. Jour. Ophth., 1942, v. 25, June, pp. 672-684; also Trans. Amer. Ophth. Soc., 1941, v. 39, p. 438. (4 plates, bibliography.)

Savin, L. H. **A note on two cases of megalocornea.** Brit. Jour. Ophth., 1942, v. 26, June, p. 265.

Megalocornea is reported in a patient aged 58 years, and in his grandson. The family history disclosed that the older patient also had an uncle with megalocornea. There was no consanguinity in the family and no defect of intelligence.

Successful intracapsular cataract extraction was performed bilaterally for the grandfather. A review of the reported cases of megalocornea complicated by cataract is appended.

Edna M. Reynolds.

Sorsby, Arnold. **The etiology of phlyctenular ophthalmia.** Brit. Jour.

Ophth., 1942, v. 26, April, pp. 159-179; and May, pp. 189-215.

An exhaustive review of the literature reveals that within living memory phlyctenulosis has declined greatly. Several large series of cases show that the disease is essentially one affecting children and young adults and occurring more commonly in girls than in boys, the ratio being about 6 to 4. An increase in the number of cases in the spring has been noted by many observers.

A discussion is given of the following causal factors: (1) nutritional deficiency, (2) focal sepsis, (3) pediculosis capitis, (4) endocrine disturbances, and (5) tuberculosis. No valid evidence for the first four could be adduced from the literature, but a mass of evidence is presented implicating tuberculous infection as the cause of phlyctenulosis.

No observer has found less than 70 percent of positive tuberculin reactions, and X-ray studies of patients with phlyctenulosis show a high incidence of active tuberculous chest lesions. A history of clinical tuberculosis is reported in as high as 50 percent of their cases by some observers and a high incidence of family tuberculosis is also reported. The after history of patients with phlyctenular ophthalmia shows a mortality rate almost twice the normal.

No observer has reported the presence of tubercle bacilli in the phlyctenule. Also, experimental attempts to produce tuberculous lesions by inoculation with material from the phlyctenule have been fruitless.

Personal investigations carried out by the author at White Oak Hospital from 1935 to 1940 and an analysis of the cases of phlyctenular ophthalmia treated there between 1921 and 1940 disclosed positive tuberculin reactions in over 80 percent of all phlycten cases and radiologic evidence of tuberculosis in 72 percent of the cases. A family history of tuberculosis was present in 28.9 percent of the cases and the sedimentation rate was raised in 79.8 percent of the cases with active phlyctenular ophthalmia. Tubercle bacilli could not be recovered in the stomach washings of fifty cases nor in the excised tonsils of twenty others.

It is concluded that phlyctenular ophthalmia is a manifestation not of tuberculous disease but of tuberculous infection, the phlyctenule making its appearance only when a hyperallergic phase is present and there is a suitable exciting factor of endogenous or exogenous origin. (Tables, bibliography.)

Edna M. Reynolds.

Tschetschik-kunina, E. A. **Keratoplasty in serpent and other corneal ulcers.** Ophthalmologica, 1942, v. 103, Jan., p. 1.

Full-thickness grafts had beneficial effects on pneumococcus ulcers of the cornea produced experimentally on rabbits. Fifteen patients were similarly treated, with satisfying results. Pain, redness, infiltration, and opacity gradually disappeared. In most of the 15 rather severely infected eyes, the eyeball was saved and in about one half of these satisfactory visual acuity resulted. Opacity of the transplant, anterior synechiae, and increased intraocular pressure were the chief complications which prevented restoration of good vision. The author believes that results would be much more favorable if keratoplasty were resorted to more frequently in mildly affected eyes. Nonpenetrating keratoplasty is not effective.

F. Herbert Haessler.

7

UVEAL TRACT, SYMPATHETIC DISEASE, AND AQUEOUS HUMOR

Gartner, Samuel. **Anomalous processes of the ciliary type on the posterior surface of the iris.** Amer. Jour. Ophth., 1942, v. 25, July, pp. 854-857. (5 figures, references.)

Gartner, Samuel. **Displacement of ciliary processes to the posterior surface of the iris.** Amer. Jour. Ophth., 1942, v. 25, July, pp. 858-860. (One figure, references.)

Guyton, J. S. **Etiological diagnosis of uveitis.** Mississippi Doctor, 1941, v. 19, Nov., p. 292. (See Amer. Jour. Ophth., 1942, v. 25, April, p. 502.)

Herrmann, H., and Friedenwald, J. S. **The choline-esterase content of the choroid plexus and ciliary processes.** Bull. Johns Hopkins Hosp., 1942, v. 70, Jan., p. 14.

These tissues, which constitute the source of intraocular fluids, were examined for their enzyme content. Choline esterase was extracted from beef and pig eyes and, while the choroid plexus and the processes of the ciliary body showed moderate and similar choline-esterase activity, there was no evidence that the secretory activity of either organ was cholinergic.

F. M. Crage.

Löwenstein, Otto, and Friedman, E. D. **Pupillographic studies. 1. Present state of pupillography; its method and diagnostic significance.** Arch. of Ophth., 1942, v. 27, May, pp. 969-993. (See Section 1, General methods of diagnosis.)

Marucci, Luigi. **Recurrent hypopyon-iritis and skin lesions.** Boll. d'Ocul., 1940, v. 19, May, pp. 355-366.

A woman of 36 years had been affected for several years by recurrent bilateral attacks of iritis with hypopyon. General examination showed suppurative skin lesions around the nose, and a necrotic gingivitis with pyorrhea. In spite of study of general findings, laboratory research, and local and general treatment, the etiologic factor could not be determined. Treatment was of no avail. The writer concludes that at present the real nature of this entity is unknown. (Bibliography, 5 figures.) M. Lombardo.

Sachs, E. **The pharmacological behavior of the intraocular muscles. 4. The action of strychnine on the dilator and sphincter iridis.** Jour. Pharm. and Exper. Therap., 1942, v. 74, March, pp. 262-265.

Strychnine (1 to 50,000) produced neither contraction nor relaxation in 13 albino-rabbit sphincter strips, and 6 dilator preparations. In adrenaline-contracted dilator strips, strychnine produced a relaxation. In acetylcholine-contracted sphincter strips, a second contraction was produced. In eserine-contracted sphincter strips, the results were variable. The author concludes that the effects of strychnine on the isolated iris muscles cannot at present be related to their known adrenergic and cholinergic mechanisms, and the possibility exists that strychnine acts quite independently of those mechanisms. T. E. Sanders.

Weskamp, Carlos. **Chorioretinitis serosa macularis.** Anales Argentinos de Oft., 1941, v. 11, July-Aug.-Sept., p. 143.

The author reviews the earlier literature on this subject and reports nine cases personally studied. All were between twenty and forty years old, and eight were males. Cases were studied

clinically and radiologically and all were tuberculin-sensitive. Twenty-two percent had definite pulmonary lesions. The disease lasted from two to four months and resulted in perfect cure in all cases. All received tuberculin therapy. The author believes that the condition is not always tuberculous but is dependent upon an allergic basis, in which other organisms may set free a tuberculous toxin. (9 photographs.)

Eugene M. Blake.

8

GLAUCOMA AND OCULAR TENSION

Bangerter, A., and Goldmann, H. **Gonioscopy in primary glaucoma in relation to choice of operation.** Ophthalmologica, 1941, v. 102, Dec., p. 321.

The authors use Goldmann's contact glass, which has a mirror incorporated in it so that the entire chamber angle is accessible to inspection at the slit-lamp without any further apparatus. Their method of conducting an examination is given in detail. They describe the normal chamber angle and in particular the landmarks which undergo changes or are useful for orientation in glaucomatous eyes, namely Schwalbe's ring, corneoscleral trabeculum, ciliary body, and iris. The region of Schlemm's canal in the trabeculum may often be red, presumably because of hemorrhage caused by pressure of the contact glass. The form of the chamber angle is easily classified as wide or open, medium, and slit-like. The visible portion of the ciliary body may often be covered by a gray veil. Also seen are: pigmentation of the region of the trabeculum, narrowing of the angle so that the iris root is contiguous, and the Schwalbe ring and true pigmented synechiae which bind the iris root to the cornea. In simple glaucoma the chamber angle was almost always open, though in slightly more than half of the authors' patients there were such changes as pigmentation and veiling of the ciliary body. In decompensated glaucoma, the angle was fully closed during an attack. Where medical treatment effected a reduction in tension to normal, the angle became open, though very narrow, and its characteristic landmarks became visible.

Examination of eyes with primary glaucoma on which surgery has been performed shows that iridectomy works by freeing the corneoscleral trabeculum. It succeeds only when it is truly basal and includes the iris root. It is the operation of choice in decompensated glaucoma with closure of the chamber angle while the tension is increased. Cyclodialysis succeeds only when the chamber angle is not too narrow. It is the operation of choice in glaucoma simplex with open angle. In inflammatory glaucoma in which iridectomy has not reduced tension to normal values, a cyclodialysis at the site of the iridectomy often succeeds. In primary simple glaucoma with narrow chamber angle it is advisable to do a preliminary basal iridectomy to prevent postoperative closure of the cyclodialysis, and to do the cyclodialysis in the surgical coloboma.

F. Herbert Haessler.

Corrado, M. **On the diverse factors that determine the variable behavior of the excavation of the papilla in glaucoma, in relation to the histopathogenic mechanism thereof.** Ann. di Ottal. e Clin. Ocul., 1941, v. 69, Jan., pp. 27-58, and March, pp. 129-174.

This investigation is based on the histologic study of eyes with absolute glaucoma. Fifteen such eyes are reported upon at length.

Corrado supports the concept that at

least in a certain number of cases, even of advanced glaucoma, the excavation may be limited to the prelaminar tissue, without any retrocession of the lamina cribrosa itself. The behavior of the prelaminar tissue plays an important part in the development and form of the excavation. Lacunar degeneration of the optic nerve is a factor, since it may cause incidentally a place of lowered resistance. Other factors influencing the aspect and degree of the excavation may be found in the scleral canal, the sheaths of the optic nerve, the peripapillary choroid, the sclera, and the circulatory system of the optic nerve. These factors, some of which are congenital and others acquired, may act independently of the clinical form of the disease and of the duration and degree of the intraocular pressure. In the opinion of many, glaucomatous cupping begins temporally because the temporal side of the disc, being poorer in fibers and less protected by the vessels, is less resistant. But the varying conformation of the scleral canal also is a factor in determining in what part of the papilla the excavation begins. The axes of the right and left scleral canals generally converge posteriorly, so that the optic nerve makes an acute angle with the sclera on the nasal side. Hence generally the papilla is more resistant on this side, being better supported by the underlying nerve. Another factor affecting the excavation is to be found in the state of the walls of the retinal vessels and in the relation of this state to the degree of intravascular pressure. Great rigidity of the walls when the intravascular pressure is low causes notable trophic disturbances in the nerve; likewise weak arterial walls are more exposed to the traumatizing effect of increased intraocular pressure. Harry K. Messenger.

Fortin, E. P. **Treatment of glaucomatous diseases.** Arch de Oft. de Buenos Aires, 1941, v. 16, June, p. 316.

The author reviews the different types of antiglaucomatous operation and demonstrates, by means of pathologic sections, the mechanism by which they influence intraocular pressure. The paper does not lend itself to abstracting. (13 photomicrographs.)

Plinio Montalván.

Neblett, H. C. **Diminished intraocular tension.** Southern Med. and Surg., 1942, v. 104, April, p. 220.

This condition may be due either to an alteration in the supportive structures of the eye or to a diminution in the volume of its contents. Lowered tension is usually the result of disease of or injury to the globe itself but may arise from remote injury to the sympathetic nervous system or to the skull. The occurrence of diminished pressure in diabetic coma is a matter of considerable diagnostic importance and should be searched for in every case of unconsciousness. John C. Long.

Neblett, H. C. **Glaucoma simplex without increased intraocular tension.** Southern Med. and Surg., 1942, v. 104, Feb., p. 84.

The author states that a tension maintained above 25 mm. and as low as 27 to 30 mm., even in the absence of other evidence of glaucoma, justifies a diagnosis of glaucoma simplex and warrants a searching investigation. Various provocative tests for glaucoma are discussed. The case of a thirty-year-old woman is reported to illustrate the occurrence of glaucoma with low pressure. This patient had had dull pain in the eyes and brows for three years. A moderate amount of cupping was observed and the pressure of the right eye

was 25 and the left 27 mm. (Schiötz). The fields were greatly contracted. Treatment consisted of 0.5 percent pilocarpine in association with rest, diet, and elimination. Under this regimen the subjective symptoms disappeared and the visual fields considerably increased. John C. Long.

Randolph, M. E., and Robertson, G. **Surgical treatment of glaucoma.** Southern Med. Jour., 1942, v. 35, April, p. 352.

The glaucoma cases of the Wilmer Institute were studied to determine the relative value of the trephine and the iris-inclusion operation. Atypical and complicated cases were excluded from the series. Glaucoma in Negroes was not included because of the notoriously unsatisfactory course of the disease in these people. The early cases of glaucoma responded favorably to operation in over 85 percent of the cases but operation succeeded in only 37 percent of the advanced cases. The trephine and the iris-inclusion operation seemed to be equally effective and to have the same limitations. John C. Long.

Reese, A. B., and McGavic, J. S. **Relation of field contraction to blood pressure in chronic primary glaucoma.** Arch. of Ophth., 1942, v. 27, May, pp. 845-850.

A series of 132 eyes with chronic primary glaucoma were studied, prior to any operative procedure, as to the relation of the intraocular pressure and the retinal systolic and diastolic arterial pressure to the rate of contraction of the visual fields. To facilitate the comparison of the fields with the other factors, the amount of visual field retained was estimated in percentage, with the planimeter. The relation of the systolic and diastolic pressures to the intraocular pressure was expressed in the form of a coefficient derived from dividing the former by the latter. It was found that a systolic coefficient of from 5.75 to 6.0 or higher and a diastolic coefficient of from 3.25 to 3.50 or higher might be regarded as normal. Since the coefficients are not always consistent, it is possible for patients with coefficients in these normal ranges or higher to show contraction of the visual fields. However, coefficients within these specified normal ranges or higher, indicate that the retention of fields will tend to be protracted, while coefficients lower than these norms indicate that the loss of fields will tend to be rapid. Systolic and diastolic coefficients appeared to be of equal significance. The details in the series of cases are tabulated as to percentage of field retained, systolic coefficient and diastolic coefficient. The authors point out that the coefficients determined in this study cannot be accepted unconditionally since there were sources of error, such as inability to determine the duration of the glaucoma, or the extent to which miotics had been used, the variability in the blood pressure and intraocular pressure and the possible influence of sclerosis of the retinal vessels. The results merely indicate a trend toward a relation between intraocular pressure, the blood pressure, and the contraction of the visual field.

J. Hewitt Judd.

Swan, K. C. **Advances in the medical treatment of glaucoma.** Jour.-Lancet, 1942, v. 62, March, pp. 79-82.

Swan discusses the new agents, new combinations of new and old drugs, and improved methods of administration that have widened the scope of medical treatment in glaucoma. In advanced glaucoma simplex, doryl in

zephiran solution and concentrated epinephrine have increased considerably the effectiveness of medical treatment either as an alternative or adjunct to surgery. The use of doryl has been particularly encouraging. In the preoperative treatment of acute congestive glaucoma, mecholyl has not proved more effective than eserine but systemic reactions from it are less apt to occur. In an occasional case, combinations of mecholyl and eserine, or of mecholyl and prostigmine, may be more effective than these drugs alone. In the use of hypertonic solutions, the author found that glucose and saline were ineffective, that sucrose produced renal damage, and that sorbital was the only suitable agent, although its value was limited. T. E. Sanders.

Weekers, Roger. **Ocular symptoms of insufficiency edema.** Ophthalmologica, 1942, v. 103, Feb., p. 81.

In 15 patients with insufficiency edema the intraocular tension was normal or low despite low plasma-protein content or reduction of albumin-globulin relationship. This observation does not support the theory that the aqueous is a simple dialysate. Epidemic glaucoma which is accompanied by edema cannot be attributed only to changes of plasma proteins. As in the hypertension which is often observed in angioneurotic edema, the vascular factors probably are decisive.

F. Herbert Haessler.

9

CRYSTALLINE LENS

Huysmans, J. H. B. M., and Fischer, F. P. **On the causes of the high vitamin-C concentration in aqueous and lens.** Ophthalmologica, 1942, v. 103, Jan., p. 21.

In a previous communication (Amer. Jour. Ophth., 1942, v. 25, p. 767) the authors presented evidence to show that the surviving lens is capable of producing, in vitro, considerable quantities of vitamin C from carbohydrates. It seems probable, therefore, that the lens is the source of the high vitamin-C content of the aqueous. There is great difference of opinion on the subject, however, and in the literature one finds three other views, all supported by experimental evidence. In the present essay the authors present further evidence and a critical evaluation of the findings of others. They conclude that the activity of the lens is indeed the source of aqueous vitamin C. Neither the theory of the irreciprocal permeability of the blood-aqueous barrier of oxidized vitamins suggested by Goldmann and Buschke nor the parasympathetic theory of Bonsignor is tenable. Vitamin C is almost always present in the blood stream in the reduced form. Adrenaline decreases the concentration of aqueous vitamin C by oxidation, and not by rendering impermeable the blood-aqueous barrier; while atropine increases it. In the aphakic eye the aqueous concentration of vitamin equals that of the blood. The vitamin production may be kept up by newly formed lens elements. In cataract the concentration of vitamin C in aqueous and lens depends on the amount of opacity. It can remain normal only in nuclear cataract with functioning cortex. The lens may not only produce vitamin C, but may reduce large quantities of oxidized vitamin C. It is shown that there is an external circulation of aqueous into the lens and back in which vitamin C is being repeatedly reduced and a similar internal cycle within the lens. These cycles of activity are important sources of energy and show

that vitamin C functions as an energy-producing reversible oxidation-reduction system. This has been assumed for some time, but has never been proved before. F. Herbert Haessler.

Milano, Archille. **On the phosphor-bearing power of the transparent and cataractous human crystalline lens.** Ann. di Ottal. e Clin. Ocul., 1941, v. 69, March, pp. 175-181.

In this article are presented the conclusions of a study of the power of the human lens to form phosphoric-acid esters with glucose.

The normal human lens has a high phosphorus content, which is about the same in nuclear cataracts, but is reduced in cortical cataracts. In cataracts the ratio of organic to inorganic phosphorus is increased, more especially in the nuclear variety. The power to form phosphoric-acid esters with glucose is about the same in normal lenses and in cortical cataracts, but in nuclear cataracts is slightly though constantly reduced. Harry K. Messenger.

10

RETINA AND VITREOUS

Baird, J. M., and Clay, G. E. **Interpretation of the hypertensive fundus.** Southern Med. Jour., 1942, v. 35, Feb., pp. 199-203.

The authors believe that essential hypertension may be divided into two distinct types, benign and malignant, which may be distinguished by the fundus picture. They describe four grades of each type based on the degree of fundus change present. They believe that a more precise classification of hypertensive fundus lesions would be of great aid in the diagnosis and prognosis of the condition. T. E. Sanders.

Haig, C., and Patek, A. J., Jr. **Vitamin-A deficiency in Laënnec's cirrhosis. The relative significance of the plasma vitamin-A and carotenoid levels and the dark-adaptation time.** Jour. Clin. Investigation, 1942, v. 21, May, p. 309.

Dark-adaptation time, concentration of vitamin A, and total carotenoid in the blood plasma were investigated in 49 patients with Laënnec's cirrhosis and in 38 patients with various other diseases. Six cirrhotic livers were also examined for vitamin-A and carotenoid content.

The authors conclude that Laënnec's cirrhosis shows a greater deficiency in vitamin A, total carotenoid in the blood and liver, and dark-adaptation time than do the mixed group of diseases investigated. The variable most markedly influenced by the presence and severity of Laënnec's cirrhosis is the blood vitamin-A level. F. M. Crage.

Liu, I. S. **Progressive familial macular degeneration.** National Med. Jour. China, 1942, v. 28, p. 129.

Familial macular degeneration is a rare disease condition. The author's patient showed greenish-gray opacities associated with pigmentation in the macular region of both eyes. Fine white dots looking like stars twinkling in the sky were observed in the retinas. A central scotoma was found in the right eye and a ring scotoma in the left eye. After treatment with anterior pituitary hormone, both eyes showed a ring scotoma. The vision improved from 0.1 to 0.2 in the right eye and from 3m/0.1 to 0.2 in the left. Hormone therapy seems to have been helpful in this case. A colored drawing of the fundus of the left eye accompanies the original paper. K. S. Sun.

Sédan, Jean. **Retinal hemorrhage after smoking potato leaves.** Ophthal-

mologica, 1941, v. 102, Dec., p. 361. (See Section 16, Injuries.)

Traina Rao, G., and Casa' Girolamo. **The action of nicotinic acid on some manifestations of the eclamptic state (retinal angiospasm).** Boll. d'Ocul., 1940, v. 19, May, pp. 407-436.

A 28-year-old pluripara affected at the seventh month of gestation by general symptoms of nephritis showed marked narrowing of limbus arterioles, marked ischemia of the disc, and a diffuse spasm of retinal arteries with edema of the retina. The intramuscular use of nicotinic acid in the amount of 60 mg. every 12 hours brought the local and general conditions to normalcy in 12 days. The history is also given of a multipara, 28 years of age, who had nicotinic-acid therapy associated with general hypotensive therapy; and of another multipara, 42 years of age, whose pregnancy had to be terminated due to a severe toxicosis. The nicotinic treatment gave complete recovery of the eye symptoms in both cases. The authors think that nicotinic acid eliminates the crises of retinal angiospasm with solitary hypertension in this territory, and that it improves the flow of blood in the fundus and increases the effects of the general hypotensive therapy which by itself cannot modify the retinal hypertension. (Bibliography.)

M. Lombardo.

11

OPTIC NERVE AND TOXIC AMBLYOPIAS

Mao, W. S. **Gumma of the optic papilla.** National Med. Jour. China, 1942, v. 28, p. 119.

There are less than twenty cases of gumma of the optic papilla reported in the literature of the world. This paper describes one case, which is the first of its kind found in China. It was seen in a male patient, aged thirty years, who gave a history of a chancre growing on his genitalia three years prior to the ocular affection. The Kahn test was strongly positive. Iritis with posterior synechiae was present. Ophthalmoscopic examination revealed a large, yellowish-white mass with ill-defined margins covering the papillary region. This mass measured twice the size of the disc, protruding 8.00 D. into the vitreous. Splotches of flame-shaped hemorrhage were visible at its inferotemporal periphery. In addition to receiving local treatment, the patient was given antisyphilitic medication. Subsequently the tumor disappeared. The vision in the affected eye improved from barely discerning hand movements to counting fingers at 2 m. Illustrations of the fundus before and after treatment are incorporated in the original article.

K. S. Sun.

Moore, J. E., Hahn, R. D., Woods, A. C., and Sloan, L. **The treatment of syphilitic primary optic atrophy.** Amer. Jour. Ophth., 1942, v. 25, July, pp. 777-823. (13 figures, 22 tables, references.)

Secunda, L., and Trowbridge, E. H., Jr. **The occurrence of polyneuritis and abnormal pupillary reactions in chronic alcoholism.** Quarterly Jour. Studies on Alcohol, 1942, v. 2, March, pp. 669-671.

A series of 641 patients with chronic alcoholism, of whom 461 had psychosis, is reviewed. In the total series, 17 percent had polyneuritis and 44 percent had anomalous pupils. Pupillary anomalies were more frequent in those cases with psychosis. Both polyneuritis and pupillary anomalies occur more frequently in those alcoholic psychoses in which there is marked mental confusion.

T. E. Sanders.

Whalman, H. F. **Retrobulbar neuritis.** Southwestern Med., 1942, v. 26, May, p. 157.

This is a general review of the subject with discussion of the etiology, diagnosis, and treatment. The author accepts Duggan's view that acute retrobulbar neuritis is due to tissue anoxia from angiospasm. Almost any substance which is poisonous to tissues may be causal. There seems to be little relationship between neuritis and sinusitis in most cases. Treatment consists largely of the administration of vitamin-B complex and of vasodilators. Sodium nitrite is recommended as a vasodilator. There does not seem to be any justification for sinus surgery in the absence of definite sinus disease.

John C. Long.

12

VISUAL TRACTS AND CENTERS

Argañaraz, Raul. **Heteronymous hemianopsias with intracranial tumors in the neighborhood of the chiasm.** Arch. de Oft. de Buenos Aires, 1941, v. 16, July, p. 349.

The author presents a very thorough study of the subject under the following headings: (1) Intrasellar tumors: adenoma of the hypophysis and hypophyseal cyst, or craniopharyngioma; (2) Extrasellar or parasellar tumors: meningioma, aneurysm, or vascular lesions of the arterial circle of Willis, and parasellar arachnoiditis. The symptomatology, diagnosis, and treatment are discussed in detail, and several illustrative cases are reported. (Visual-field charts.)

Plinio Montalván.

Evans, J. N. **The present status of angioscotometry.** Amer. Jour. Ophth., 1942, v. 25, July, pp. 861-865. (Bibliography.)

13

EYEBALL AND ORBIT

Bakker, A. **Does carbonic-acid anhydrase in the eye tissues produce a hydration of carbon dioxide or a dehydration of carbonic acid?** Ophthalmologica, 1942, v. 103, Feb., p. 88.

The enzyme carbonic-acid anhydrase catalyzed the balanced reversible reaction $H_2CO_3 = CO_2 + H_2O$ in both directions. Several substances are known which activate this enzyme action in both directions—cystein, histidine, histamine, and glutathione. In the lens and retina, dehydration occurs more readily than hydration.

F. Herbert Haessler.

Berens, S. N. **Surgical approach to meningiomas in the region of the sphenoid ridge causing unilateral exophthalmos.** Western Jour. Surg., Obstet., and Gynecology, 1942, v. 50, May, p. 225.

Comments on other surgical techniques are followed by a description of the Swift modification of the Krönlein as successfully employed in the author's case. (5 illustrations).

F. M. Crage.

Daily, R. K., Daily, L., Walker, J. D., and Peterson, H. J. **Exophthalmic ophthalmoplegia.** Southern Med. Jour., 1942, v. 35, April, p. 344.

This condition was first described by Brain in 1938 as a syndrome consisting of progressive bilateral exophthalmos and ophthalmoplegia followed by secondary visual disturbances. The disease may occur independently of or concurrent with hyperthyroidism. The pathologic changes noted consist of venous engorgement and edema and suggest a pathogenesis similar to that of acute inflammatory glaucoma. Treatment com-

prises adequate decompression of the orbit either into the paranasal sinuses or into the cranial cavity. Decompression into the sinuses is safer and simpler than intracranial decompression and should be done when the frontal sinuses are of adequate size. Three cases are reported, one of which was associated with hyperthyroidism.

John C. Long.

Damel, C. S., and Taullard, O. **Oculopalpebral prothesis.** Arch. de Oft. de Buenos Aires, 1941, v. 16, June, p. 336.

The authors describe a prothesis they designed for a young woman who had had complete exenteration of the orbit including the lids. After epidermization of the cavity, an artificial eye anchored to a special spectacle frame was worn with very good cosmetic result. (Illustrations.) Plinio Montalván.

Moore, G. B., Jr., Gardner, J. D., and Bell, K. R. **Cavernous-sinus thrombophebitis.** Jour. Amer. Med. Assoc., 1942, v. 119, June 27, p. 708.

In a case of cavernous-sinus thrombophlebitis the maintenance of a sustained concentration of sulfathiazole in the blood of 25 to 33 mg. per hundred c.c. resulted in complete cure even after the development of pulmonary abscesses and arterial embolism.

George H. Stine.

14

EYELIDS AND LACRIMAL APPARATUS

Agatston, S. A. **Resection of levator palpebrae muscle by the conjunctival route for ptosis.** Arch. of Ophth., 1942, v. 27, May, pp. 994-996.

After instillation of pontocaine or cocaine solution, the eyelid is injected with 2-percent procaine-hydrochloride solution. The upper lid is grasped with an Ehrhardt clamp forceps and everted. The tarsus is incised clear across, 3 mm. below the upper margin, using care not to cut through the anterior layer of the levator tendon. The pretarsal space behind the levator tendon is thus exposed. The tarsus is freed up to the upper margin and Müller's muscle is separated from the anterior lamella of the tendon by dull dissection. By cutting through the attachment of the posterior lamella to the upper margin of the tarsus, the conjunctiva is dissected free of the two layers of the levator tendon, which remain in close contact with each other. Holding the cut tarsus on tension, dissection of the conjunctiva is continued up to the fornix until the loose areolar tissue behind the muscle is reached. The posterior surface of the combined muscle-tendon is picked up with a forceps near the lower cut edge of the tarsus. A careful nick will expose the anterior line of cleavage between the levator tendon and the orbicularis muscle. The tendon is then slit across parallel to the cut edge of the tarsus. The broad tendon is dissected from the posterior surface of the orbicularis until areolar tissue is again reached and the membranous tendon freed. Three double-armed sutures are passed through with the loop on the inner surface, one central and two lateral. The level of these sutures determines the degree of resection. The higher on the tendon the sutures are placed the stronger is the effect. The tendon is then resected 2.5 mm. below the sutures. The conjunctiva, with the resected tarsus, is sliced off at a corresponding level. All needles are then passed through between the tarsus and the skin, to emerge 2 mm. above the lid margin, and the sutures are tied over a small gauze roll. Conjunctival sutures are not absolutely

necessary, as the conjunctiva falls into place. Separate sutures may be introduced at the end of the operation. With the retraction of the lid by this operation, the fold in the lid forms spontaneously. To insure this fold, the operator may pass a single basting suture through the skin and the orbicularis muscle at the proper level. The conjunctival sac is filled with sterile petrolatum and a cone dressing applied. The dressing should be removed after 24 hours and only protective petrolatum used. J. Hewitt Judd.

Berens, Conrad. **Lacrimal canaliculus dilator.** Amer. Jour. Ophth., 1942, v. 25, June, p. 725. (One illustration.)

15

TUMORS

Bellecci, Paolo. **Primary epithelioma of the cornea.** Ann. di Ottal. e Clin. Ocul., 1941, v. 69, March, pp. 182-192.

This report of a case of primary epithelioma of the cornea includes the histologic examination and a diagnostic discussion. The term "initial" is used in accordance with the histogenetic classification of Poleff. The tumor in question belonged exclusively to the cornea, being 2 mm. from the limbus. The intervening strip of cornea was traversed by a few tufts of superficial vessels growing from the conjunctiva into the tumor. Bellecci surmises that the neoplasm was originally a papilloma, which later underwent malignant transformation. Harry K. Messenger.

Regoli, A. **Primary melanosarcoma of the cornea.** Boll. d'Ocul., 1940, v. 19, May, pp. 367-389.

A woman of 76 years had shown for about a year, on the cornea of the left eye, a hard slowly growing trilobate neoformation which measured 8 by 10 mm. and was elevated 8 mm. from the surface of the cornea. The mass was brown at the periphery and dark gray at the center. No enlargement of parotid or submaxillary glands was noted. The tumor was diagnosed as a primary fuso-cellular melanotic sarcoma of the cornea in a globe affected by absolute glaucoma. A detailed description of the microscopic appearance is given. The writer closes with a discussion on the histogenesis of the pigment of the sarcoma and the chemical genesis of the melanin. (Bibliography, 6 figures.) M. Lombardo.

Rottino, Antonio, and Kelly, A. S. **Primary orbital melanoma.** Arch. of Ophth., 1942, v. 27, May, pp. 934-949.

A review of the literature since 1838, discloses that most reports of primary orbital melanoma are brief and pathologic studies are either absent or incomplete. The collected reports are tabulated and brief notes of criticism given. Eleven cases from the literature are summarized. The case of a young man aged 27 years, presenting a primary orbital melanoma, is reported. He gave a history of proptosis which had slowly developed until the past year when it had seemed to grow more rapidly. A soft mass, filling the orbit, could be felt through the lid. X-ray studies of the skull gave negative results. At operation the orbit was found to be completely filled by a tarry mass which hugged the eyeball closely, making enucleation impossible. A complete exenteration was done. Postoperative course was uneventful. Several radium treatments were given. The orbit filled in nicely with healthy granulation tissue. There was no evidence of recurrence or metastasis after nearly two years. Two types of tissue were found in the tumor. One, colorless and cystic,

was centrally located, and was composed of nonpigmented, spindle and stellate cells; while the other consisted of normal orbital contents enlarged to tumor proportion by massive and diffuse infiltration of cells packed with pigment, giving it a pitch-black color. The authors believe that since this portion could be readily peeled off from both the eyeball and the colorless part of the tumor, there was no close relationship between the two parts. In their opinion the majority of the cells constituting the black part of the growth were chromatophores (macrophages) rather than neoplastic melanoblasts. (Bibliography.)

J. Hewitt Judd.

16

INJURIES

Chan, Eugene. **Arsenical exfoliative conjunctivitis and keratitis.** National Med. Jour. China, 1942, v. 28, p. 114.

A description of arsenic poisoning may be found in the old Chinese book, Hsi Yuan Lu, written by Sung Tzu in 1241-1253 A.D. The ocular signs given are hemorrhage and exophthalmus. These are only late signs. During recent years, attention has been called to the fact that exfoliate dermatitis may be a complication of arsenic poisoning. Associated with such a dermatitis, there is often developed a conjunctivitis which may be properly named exfoliative conjunctivitis. On rare occasions, the cornea may also be involved, thus giving rise to exfoliative keratitis. One of the earliest signs of poisoning or hypersensitiveness to arsenic and its derivatives is congestion of the palpebral conjunctiva or circumcorneal congestion. Practitioners are reminded that they should watch for such signs when administering arsenical drugs. A case of exfoliative dermatitis with exfoliative conjunctivitis caused by ingestion of spirocid is reported in detail. Idiosyncrasy to this drug with involvement of the conjunctiva has not been recorded in the literature. Another case of exfoliative conjunctivitis and exfoliative keratitis following intravenous injection of neoarsphenamin is described. There are less than ten cases of arsenical exfoliative keratitis reported in the literature of the world. K. S. Sun.

Cowen, J. P. **Cilia implantation in anterior chamber through traumatic corneal perforation.** Amer. Jour. Ophth., 1942, v. 25, June, pp. 721-724. (2 illustrations, references.)

Damel, C. S., and Teruggi, A. **Subconjunctival luxation of the lens.** Arch. de Oft. de Buenos Aires, 1941, v. 16, July, p. 400.

Two cases of subconjunctival luxation of the lens of traumatic origin are reported. In the first case the luxated lens was expelled through a conjunctival wound when a prolapse of the conjunctiva was resected three days after the accident. The globe gradually became atrophic. In the second case the lens could be seen beneath the bulbar conjunctiva on the temporal side and was extracted surgically with good result. (Bibliography.)

Plinio Montalván.

Fridenberg, Percy. **First aid in eye injuries: a measure of civilian defense.** Dis. Eye, Ear, Nose, and Throat, 1942, v. 2, May, p. 134.

Injuries in wartime are much the same as those incurred in peacetime, only the etiology differs. Because of this, some modifications in protection, prevention, and treatment become necessary.

Efficacy of air-raid warnings as a protection-defense mechanism is important. Practical instruction on what to do in an air raid is essential. The British have shown that by simple means the incendiary bomb can be safely and easily extinguished.

First aid is described in general. The essential needs in a first-aid kit are mentioned.

Perfect coöperation must exist between airplane spotters, air-raid wardens, police and fire departments, and first-aid workers and physicians.

F. M. Crage.

Mann, Ida. **Mustard-gas lesions of the eyes.** Brit. Med. Jour., 1942, March 14, pp. 353-354.

The effects of mustard gas on the eyes depend on the size of the dose and the structures involved. The series of changes set up by the gas tends toward self-limitation and spontaneous recovery, the results being better than the original condition would suggest, even in severe cases incapacitated for months. The author recommends that the treatment shall be symptomatic, since the condition is a chemical injury with possible late secondary degenerative changes. The patient should be reassured as to the ultimate outcome, as the prognosis is good unless the corneal injury is extreme. T. E. Sanders.

Petronio, G. **Alterations in the cornea from emetine.** Ann. di Ottal. e Clin. Ocul., 1940, v. 68, Dec., pp. 914-926.

The effect is described of a 5 percent solution of emetine hydrochloride applied locally to the eye of one person (accidentally) and to the eyes of three rabbits. In each case a corneal lesion, essentially an edema of the epithelium of the superficial lamellae, appeared after a latent period of 12 to 24 hours. Petronio concludes that the alterations in the cornea were not due to the direct action of the emetine but were the result of a trophic disturbance caused by vasodilator action upon the small vessels of the conjunctiva and especially the capillaries of the circumcorneal vascular network. The attending hypesthesia is cited as evidence of the trophic effect of the drug.

Harry K. Messenger.

Sédan, Jean. **Retinal hemorrhage after smoking potato leaves.** Ophthalmologica, 1941, v. 102, Dec., p. 361.

Dried potato leaves are a not uncommon tobacco substitute in southern France. The author observed five precisely identical cases of retinal hemorrhage following the smoking of potato leaves. All were observed from 8 to 15 days after the beginning intoxication without evidence of any accompanying vascular or renal affection. The retinal hemorrhages were all in the form of fine flames, and in one of the patients there were also conjunctival hemorrhages. There were also the toxic and gastro-intestinal symptoms common in inexperienced smokers. The effective poisons are solanin and solanidin. The author points out that there is retinal arterial hypertension after potato-leaf smoking, while tobacco produces hypotension. F. Herbert Haessler.

Thies, Oscar. **Old and new ideas in treating serious burns.** Klin. M. f. Augenh., 1941, v. 106, Jan., pp. 47-56.

A transplant of mucous membrane from the lip is used in cases of severe burn, where the sensitivity of the cornea is disturbed. The best time for transplanting the tissue is during the first seven hours following the accident. If the sensitivity of the cornea is not disturbed, transplanting is not indicated

even in severe burns of the conjunctiva. Eleven cases are reported all of which regained better vision than would ordinarily have been expected from the extent of the burn.

Gertrude S. Hausmann.

17

SYSTEMIC DISEASES AND PARASITES

Adson, A. W. **Surgical treatment of vascular diseases altering the function of the eyes.** Amer. Jour. Ophth., 1942, v. 25, July, pp. 824-838; also Trans. Amer. Acad. Ophth. and Otolaryng., 1941, 46th mtg., p. 95. (11 figures, bibliography.)

Roper-Hall, H. T. **Oral sepsis in relation to ophthalmology.** Brit. Jour. Ophth., 1942, v. 26, April, pp. 141-151.

The common aims of medicine and dentistry are emphasized. Various forms of dental sepsis are discussed and treatment is outlined. The author recommends that every ophthalmic hospital have a dental surgeon, who should routinely examine all patients as early as possible after their admission to the hospital. He also recommends the attendance of dental surgeons during the visiting periods of the medical staff of the hospital, and better training for medical students on the teeth and their diseases. (References.)

Edna M. Reynolds.

Spadavecchia, Vitangelo. **Nasociliary neuritis.** Ann. di Ottal. e Clin. Ocul., 1940, v. 68, Sept., pp. 668-717.

This is the first installment of a long monograph and comprises an introduction, clinical observations, anatomic notes, clinical symptomatology, and etiology. The remainder of the treatise, in which the pathogenesis, diagnosis, prognosis, and treatment, together with a summary and bibliography, are given, is not yet available to the writer of this abstract.

Two fundamental types of conditions or pathologic possibilities may occur in the nasociliary nerve, namely, those referable to an irritative state, and those referable to a state of deficit or to a paralysis. The irritative phenomena may be either simple or may be accompanied by inflammation. Those of the second type are due to interruption in the path of the nerve or may be post-inflammatory.

The term "syndrome of the nasal nerve" (or "Charlin's sydrome") has been used to designate both the simple and the inflammatory irritative phenomena, but in the light of our now greater knowledge there is reason for discarding it in favor of more precise terminology. Spadavecchia designates the two types by the terms "simple nasociliary phenomenology (or syndrome)" and "irritative-inflammatory phenomenology." The term "nasociliary neuritis," which was introduced by François, was used by him with reference to a case of what was essentially Charlin's syndrome, but may properly be extended to the whole group of neuritic conditions involving the nerve in question.

Not having found in the literature any description of the postinflammatory or atrophic-degenerative stage of nasociliary neuritis, Spadavecchia presents his own observations from which he concludes that the clinical symptoms manifested in this stage are almost exclusively of the nature of functional disturbances: hypesthesia (for touch, heat, and pain) of the cornea, the conjunctiva, and the anterior part of the nasal mucous membrane; paresthesia, appearing as formication and prickling; reduced frequency of winking; sympa-

thetic hyperexcitability; and dryness of the conjunctival sac and nasal mucosa.

The essential causes of nasociliary neuritis are infective or toxic processes, among which may be mentioned tuberculosis, rheumatism (articular and inflammatory), and focal infections; also metabolic disturbances, as gout and diabetes. Exciting causes are variations in temperature, fatigue, emotions, endocrine imbalance, intestinal intoxication, and even the mere touching of those parts of the skin and mucous membranes supplied by the nasociliary nerve. (9 case reports.)

Harry K. Messenger.

18

HYGIENE, SOCIOLOGY, EDUCATION, AND HISTORY

Carlevaro, Gianfranco. **Allvar Gullstrand's "Regarding optical images."** Ann. di Ottal. e Clin. Ocul., 1940, v. 68, Dec., pp. 927-948.

This article presents an Italian translation of Gullstrand's "Einiges über optische Bilder" (Berlin, 1926). A few notes and figures and a brief introductory remark have been added.

Harry K. Messenger.

Carlevaro, Gianfranco. **Introduction to A. Gullstrand's "Theory of monochromatic aberrations."** Ann. di Ottal. e Clin. Ocul., 1941, v. 69, Jan., pp. 59-64.

The author presents an Italian introduction, intended to accompany a translation into Italian of this among others of Gullstrand's works.

Harry K. Messenger.

Dodds, G. E. **A report on an analysis of cases at an eye clinic in Lagos, Nigeria.** Brit. Jour. Ophth., 1942, v. 26, June, p. 257.

This report is an analysis of 801 clinic cases. Conjunctival diseases were seen most often (206 cases including trachoma, spring catarrh, and purulent conjunctivitis, but only one case of phlyctenular conjunctivitis. Defective vision due to errors of refraction was found in 189 patients. Only 58 cases of cataract and 52 cases of corneal disease were referred to the clinic. There were 51 cases of foreign body seen, many of them penetrating injuries by wood splinters. Edna M. Reynolds.

Kerby, C. E. **Eye conditions among pupils in schools for the blind in the United States, 1939 to 1940.** Outlook for the Blind, 1942, v. 36, April, p. 16.

The author presents the seventh annual summary and analysis of data on causes of blindness obtained for the Committee on Statistics from records of ophthalmologic examinations of pupils in schools for the blind. (Tables.)

F. M. Crage.

Lavos, George. **The employment of physically handicapped under civil service.** Outlook for the Blind, 1942, v. 36, Feb., p. 4.

This article makes recommendations as to job analysis, physical requirements, medical examination of defects, and the placement of handicapped workers. (Tables.) F. M. Crage.

Leydesdorff-van Praag, L. **The blind in the Netherlands East Indies.** Outlook for the Blind, 1942, v. 36, April, p. 82.

In a population of 60 million people in the Netherlands East Indies 136,000 are totally blind, the main cause of blindness being trachoma. The population is so scattered that only a very small part can be reached by clinics established to combat this disease. Before the war, Tipseu visited the Indies once a year treating and operating on

many patients. In one district having a population of 2½ million people not one eye specialist was found. Trained nurses under supervision gave the necessary medicine and treatment, except for the more complicated and surgical cases. F. M. Crage.

Robbins, C. E. **Causes of blindness in South Dakota.** Diseases Eye, Ear, Nose, and Throat, 1942, v. 2, May, p. 156.

South Dakota has a fund matching the Federal fund to give aid to the blind between the ages of 18 and 65 years. The state has a large Indian population with a high percentage of blindness from trachoma. One third of the state's blindness is from this disease.

One table shows the distribution of blind cases by counties. Others show age, sex, race, degree of blindness, age at onset, etiology, and parts of the eye affected. Many important preventive measures are included. F. M. Crage.

Snell, A. C. **Some principles of medical ethics applied to the practice of ophthalmology.** Trans. Amer. Med. Assoc., Sec. on Ophth., 1941, 92nd mtg., p. 17.

The author discusses the violation of medical ethics involving fee-splitting and receiving rebates from the prescription of glasses. George H. Stine.

Snell, A. C., Culler, A., and Kuhn, H. S. **The field of industrial ophthalmology:** A report by the Committee of Industrial Ophthalmology of the Section on Ophthalmology of the American Medical Association. Jour. Amer. Med. Assoc., 1942, v. 118, Feb. 21, p. 610.

The Committee reports that progress with a program of visual testing and correction is being made. The program intends to close the existing gap between the industrial worker who needs medical care of eye defects and those qualified to render satisfactory ophthalmic service. George H. Stine.

Velez, Daniel M. Commemorative issue containing republication of numerous articles by Dr. Velez from the year 1916; also brief obituary notice. Anales de la Soc. Mexicana de Oft., etc., 1941, v. 14, Nov.-Dec., pp. 299-345.

The papers reproduced deal with the following subjects: surgery of the optic nerve, teaching of reading and writing to the blind, iridectomy in cataract operation, tearing in breast-fed infants from lack of development of the nasal bones, important prothetic operations of the eyeball in which conservation of the conjunctiva plays the principal part, the campimetric arc, influence of size of pupil upon extent of normal visual field.

19

ANATOMY, EMBRYOLOGY, AND COMPARATIVE OPHTHALMOLOGY

Bakker, A. **Carbonic-acid anhydrase content of the ocular tissues of several mammals.** Ophthalmologica, 1941, v. 102, Dec., p. 351.

The concentration of this enzyme in lens and retina is constant within narrow limits among different individuals of the same species but varies greatly in the tissues of different species. No relationship between enzyme concentration and vascularization of the retina could be established. It is assumed that tissues with great aërobic glycolysis and a paucity of blood vessels need a high concentration of enzyme to catalyze the rapid dissociation of carbonic acid. F. Herbert Haessler.

Crozier, W. J., and Wolf, E. **The**

wave-length sensitivity function for the zebra finch. Jour. Gen. Physiology, 1942, v. 25, Jan. 20, p. 381.

The zebra finch exhibits the same general kind of relationship between flicker excitation and wave length as is found in man ("cone" contours), with the same filters. Blue filters were a little less efficient, green a little more efficient, and red very much less efficient than in the case of man.

F. M. Crage.

Wald, George. **The visual system and vitamin A of the sea lamprey.** Jour. Gen. Physiology, 1942, v. 25, Jan. 20, p. 331.

Extracts of sea-lamprey retinas were examined, as were the remaining eye tissues, and were found to contain vitamin A_1 and A_2, the latter greatly predominant. These observations extend the phylogenetic association of vitamin A_2 beyond the capacity for fresh-water existence.

F. M. Crage.

ERRATA

Dr. Arthur Linksz has called attention to an error in the legend of Fig. 2 of his article on "Improved model of the Kukán ophthalmodynamometer," on page 705 in the June, 1942 issue of the Journal. The sixth line of the legend should read: "atmospheric pressure has an area of $(b^2—a^2)\pi$."

The C. V. Mosby Company of St. Louis has called attention to an error in the title of Dr. I. S. Tassman's book, reviewed on page 1006 in the August, 1942 issue of the Journal. It should read: "Eye manifestations of internal diseases."

NEWS ITEMS

Edited by Dr. Ralph H. Miller
803 Carew Tower, Cincinnati

News items should reach the editor by the twelfth of the month.

Deaths

Dr. Henry Christian Galster, Hudson, New York, died June 8, 1942, aged 54 years.

Dr. Edward R. Ryan, Milwaukee, Wisconsin, died June 7, 1942, aged 49 years.

Dr. George Washington Carr, Englewood, New Jersey, died June 17, 1942, aged 69 years.

Dr. John Lee Summerlin, Gainesville, Florida, died May 31, 1942, aged 52 years.

Dr. Louis Koenig, Brooklyn, New York, died May 30, 1942, aged 58 years.

Dr. Charles E. Pearson, Turlock, California, died May 30, 1942, aged 64 years.

Dr. Murison Dunn, Richmond, Kentucky, died May 16, 1942, aged 70 years.

Dr. George McIntyre, Long Beach, California, died May 3, 1942, aged 81 years.

Dr. James Beaty Griffith, Washington, D.C., died May 6, 1942, aged 51 years.

Dr. John Oliver McReynolds, Dallas, Texas, died July 7, 1942, aged 77 years.

Dr. Ernest W. Carpenter, Greenville, South Carolina, died May 29, 1942, aged 67 years.

Dr. William A. Weaver, Philadelphia, Pennsylvania, died May 18, 1942, aged 71 years.

Dr. Spencer B. Dykes, Esbon, Kansas, died March 10, 1942, aged 71 years.

Dr. Henry C. Childs, Tulsa, Oklahoma, died May 7, 1942, aged 64 years.

Dr. William A. Poole, Lexington, Kentucky, died June 2, 1942, aged 60 years.

Dr. Elmer D. Osmun, Allegan, Michigan, died April 23, 1942, aged 73 years.

Dr. C. E. Ferree, Baltimore, Maryland, whose many contributions are familiar to all ophthalmologists, died suddenly on July 26, 1942, of coronary occlusion. He was 65 years old.

Societies

The following officers were elected at the recent meeting of the Florida Society of Ophthalmology and Otolaryngology: Dr. Shaler A. Richardson of Jacksonville, president; Dr. Robert E. Repass of Miami Beach, vice-president; and Dr. Carl E. Dunaway of Miami, secretary.

The State Medical Society of Wisconsin will hold its one-hundred-and-first annual meeting in Milwaukee, September 14th to 16th. Among the speakers participating in the sessions will be: Dr. James W. White—"Diagnosis in diseases of eye muscles"; Dr. Ralph H. Woods—"Frequent causes of eye discomfort"; Dr. George E. Shambaugh—"Allergy in office eye, ear, and throat practice"; and Dr. George P. Guibor—"The practical use of prisms."

At the recent meeting of the Minnesota Academy of Ophthalmology and Otolaryngology the following officers were elected: Dr. Louis A. Nelson, Saint Paul, president; Drs. Charles W. Rucker, Rochester, and Edward D. Risser, Winona, vice-presidents; and Dr. William A. Kennedy, Saint Paul, secretary-treasurer.

The Virginia Society of Ophthalmology and Otolaryngology held its regular meeting on May 16th. Officers elected were as follows: Dr. Emmett T. Gatewood, Richmond, president-elect; Dr. Guy R. Fisher, Staunton, president; and Dr. Meade C. Edmunds, Petersburg, secretary-treasurer.

Personals

Dr. L. A. Julianelle, formerly of Saint Louis, has been placed in charge of the Division of Research of Infectious Diseases in the new Public Health Institute of the City of New York.

Dr. Francis Curie Skilling has announced the association of Dr. M. Benjamin Park in the practice of ophthalmology at 401 Ingraham Building, Miami, Florida.

At the annual meeting of the North Dakota State Medical Association held in Jamestown, May 18th to 20th, Dr. George Constans, Bismarck, spoke on "Glaucoma and the general practitioner."

Dr. Thomas R. Gagion, Pittston, was among the guest speakers at the meeting of the Ninth Councilor District of the Medical Society of the State of Pennsylvania on June 25th. The title of his lecture was "The place of the general physician in the conservation of vision campaign."

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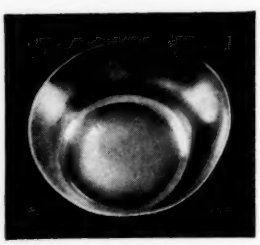

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